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REALNESS IN SCIENCE TEACHING.

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It appears to be true that the majority of our high school graduates who have spent a year in biology and another year in physics are but little more intelligent in respect to the biological and physical phenomena in their environment than their classmates who have not studied the sciences. The science students may indeed have a faint recollection of definitions and formulas and of the manipulation of rather meaningless apparatus in the laboratory, of which the others are innocent, but in the appreciation of the significance of these things in the life about them they too often have but an insignificant advantage.

This condition does not result from the difficulty of the sciences, but from the formal and symbolical manner in which they are taught. This is evident to all students of education who have given some serious thought to the subject, but I took it upon myself nevertheless to gather some informal data upon this point. I asked three of my classes, numbering in all 65 separate students, to write out for me their recollections of the way in which they had been taught two of the high school sciences. To guide them I gave them the following outline:

1. Textbook and recitation work.
2. Lectures by the teacher.
3. Laboratory work and notebooks.
4. Trips, excursions, and out-door work.

The papers that were written touched mainly the sciences of physics, chemistry, botany and zoölogy, and while there is nothing startling or unexpected in them, a few extracts may nevertheless be worth reading. I have selected especially those aspects that relate to the matter of concreteness and I have tried to make the selections fair by taking both positive and negative instances.

The sciences that I studied in the High School were biology (botany and zoölogy) and physics.

There was no outdoor work, but once a year the botany class would have an excursion to the mountains to gather specimens. The physics and zoölogy classes did not go on excursions. H. M.

In botany a textbook was used with occasional lectures. A recitation or a lecture came every day. No laboratory work was done. A notebook was kept with drawings of the dissected fruits and flowers. In the spring several excursions were made to the neighboring woods and forests. These proved unusually interesting. M. H.

In physics we used a textbook and had two recitations a week; also one lecture of forty-five minutes each.

The laboratory work consisted of two periods per week of eighty minutes each. During this time a regular manual and laboratory notebook were used.

During the year several excursions were made to the central station of the United Railway and Electric Company where observations were made and strict attention given to the generators, steam engines, traveling cranes, self-feeding machines, etc. Another interesting trip was taken to Steelton, just on the outside of the city. There we observed the building of the great Dewey, the floating drydock which was afterward carried around the world. G. M.

I have wanted to give this paper particularly because it gives a hint of the manner in which I think physics should be taught. It is the only paper of the kind that I received.

We used Gage's "Physics" as a textbook and lessons were assigned and recited every day. Points not understood were explained by the teacher. Experiments, suggested by the book, were performed in the laboratory, being afterward fully described in note books, illustrated by drawings. We never had outdoor excursions. R. P.

In the course I had in biology we used a textbook and had two recitations a week from lessons assigned in it. Once a week the teacher gave a lecture upon which I always took notes. Laboratory work came twice a week and a carefully kept notebook was required. Excursions and outdoor work there were none. J. McM.

Most of the time in botany was spent in independent laboratory work, with possibly a little hazy assignment. It seems to me I spent the greater part of this time looking through microscope for things which I either did not see or did not recognize.

During the course we had several trips to the country in the fall and spring.

The normal school course in botany was a sharp contrast to the high school course. There was practically no microscope work done and everything was handled in an elementary manner. Therefore this course quite cleared up for me many misty points from the high school course. L. C. B.

In botany the memory of lectures, laboratory work, and the arduous writing up of note books in "the best scientific manner" looms up definitely before me. We were taught to show by diagrammatic drawing exactly what we saw under the microscope.

During the two years I remember but two trips for field work, one for the identification of mosses and another for the collection of low forms of water plants. A feature that lingers vividly in my mind as incongruous was the classification of various slides of cross sections of trees

when the majority of the pupils would not have been able to recognize these same trees in a park.

The normal school course in botany began with field excursions and the gathering of material for the lesson. Then followed recourse to the various authorities previously assigned by the teacher. Lesson periods followed which were largely recitation periods, although the teacher frequently supplemented the work by comments and lectures. Laboratory work written up in note book form ran side by side with the field and recitation work. J. D. F.

In physics we followed a textbook, I know, as I bought one, but I can not remember any regular assignments or recitations.

There were certain periods when we were given lectures. These were very infrequent and often we were very far from sure what they were about, but our understanding being taken for granted, we let it go at that and asked no questions.

Of laboratory work we did a great deal. Indeed, my most distinct recollections of that course are the innumerable experiments that we performed. Sometimes I understood the principle involved, more often not. I could usually perform the experiment, but I could not always draw the conclusion. In this I was assisted very often by the teacher, who obligingly told us what we were supposed to deduce.

We kept elaborate, illustrated note books with accounts of our experiments and received marks on them. As my marks were rather high I suppose mine must have been satisfactory, but I am quite such I had no idea of any practical application of anything I learned. We took no excursions and had no outdoor work of any kind. J. L.

It is evident from these extracts that laboratory work is a common feature of high school work in science, but from reading the entire set of papers I received the impression that field trips, excursions, and out-door work are decidedly uncommon. Most of the out-door work was reported in connection with botany, only a little was reported in connection with zoölogy and physics, and none with chemistry. The botanical work in the normal school referred to stands out in delightful contrast.

From the reading of these papers it seems evident that most of the shortcomings of our science teaching in the high school may with justice be laid at the door of our high school teachers. These teachers have as yet not sufficiently availed themselves of the help they could get from the principles of education on the one hand, and from the principles of teaching on the other. They too frequently have either no clear conception of the results that should be obtained from the work in the high school sciences, or they have a wrong conception of these results; and the few who do by chance have the proper end in view do not always know how to achieve this end in an effective and consistent manner.

Educational theory has now been pointing out the fallacy of

formal culture as the primary aim of education for more than a decade, but this has so far had only a slight effect on the majority of our high school teachers. Too many of these teachers are still directing their attention to the formal effect that education is assumed to have upon the mind rather than to the content of what is learned. So approached, instruction in the sciences cannot fail to prove disappointing. The mind is not an instrument that can be brought to a formal perfection of function; it cannot be looked upon as a self-sufficient tool, but must be regarded as the mediator between the organism and its environment. Careful observation, induction and deduction, should of course be emphasized and at times be given explicit attention, but always in reference to the content taught.

When this is once fully recognized and acted upon in the schoolroom, our science teaching will no longer be disappointing. But as things now stand, the sciences, together with the other content subjects, suffer the most, because the formal subjects, like mathematics and the languages, can be taught nearly, although not fully, as well from a formal as from a contentful standpoint.

From a contentful standpoint, instruction in the sciences should first of all make the student intelligent and appreciative in respect to those aspects of life that are touched by the sciences. Biological and physical phenomena are present on every hand, not only in their raw or natural forms, but also in applied forms, and it is these phenomena that the student should learn to understand, to appreciate, and in a measure to control.

But this understanding, appreciation, and control cannot be gained merely from textbook work, not even when this is combined with laboratory work. The student must be brought into direct and practical contact with biological and physical phenomena as they exist in the world about him. The person who has studied botany, for example, should feel directly acquainted with the common flowers, grasses, weeds, shrubs, and trees in his environment, and his knowledge should be particularly thorough in respect to those plants that enter into the economic life of man. The fruits, grains, and vegetables that are raised in his neighborhood should be his intimate botanical friends.

This means, of course, that botany should be studied largely out of doors. The primary object of the work in the textbook, the classroom and and the laboratory should be to prepare the student for his field trips and for the cultivation of his garden

plot, which should always be an essential part of the course. This is what will make the work real, and consequently educative, and nothing else ever will.

The word realness needs to be redefined for the teacher. This word is by teachers commonly confused with the word objective. Teachers think that when they have referred to objects, when they have shown objects, and especially when they have allowed their classes to handle objects, that their teaching has satisfied the condition of realness; but this may be quite wrong.

Realness usually does have reference to objects, it is true, but this is not essential. Something may be real without being objective at all. Love, friendship, sympathy, and anger are real for all of us. To the historian, events that have occurred centuries ago are real, and to the mathematician x y z and the *nth* power are real. It all depends upon the person you are dealing with. The real must be defined in reference to the mind rather than to objects. All those things, whether they are material or immaterial, are real for a person with which he has had meaningful experiences. They must directly or indirectly have touched his practical or theoretical needs and made an actual difference in his life. This makes the word realness synonymous with the practical, the experiential, and the meaningful.

In reference to school work the essential criterion of realness is that the work sets a personal problem for the student. The problem must appeal to the student and solicit his spontaneous response. He must see its relation to his life and growth and must realize that its solution is to him essential as the next step in his development.

In this sense, it is clear, the most abstract relations in mathematics and philosophy may be real to the person who comes to them properly.

This conception of realness makes it clear that the demands of this word are not fully satisfied by laboratory work. In fact, this work is often quite as abstract and formal as memoritor work from the textbook. It is but another pedagogical device, albeit in principle a good one, set between the student and the content of life with which education should make the student scientifically familiar. It is in the main only a means to an end, just as the textbook is, and when this is lost sight of its essential purpose is defeated.

The textbook, and much of the laboratory work should hold the same relation to science teaching that a guide book holds to

travel. A guide book both prepares a person for what he is to see and interprets it to him. It supplements and largely takes the place of a personal guide, but it does not take the place of the sights of which it speaks. These must in the nature of the case remain the indispensable goal of travel.

In a similar manner the phenomena and applications of science must remain the goal of science teaching. It is with these things that we must begin and it is with these that we must end. The textbook and the laboratory, as well as the teacher, have their proper places in between. It is their function to effect the transition from natural phenomena conceived as disconnected, although interesting, to the same phenomena resolved into a scientific system and therefore still more interesting.

In an ideal scheme I imagine that the teacher of physics would begin the subject by taking his class on a short tour of inspection through the city to visit shops, factories, and power houses in order to see the applications of mechanics, heat, light, and electricity. At the next meeting of the class the instructor might have present on the lecture table a number of pieces of physical apparatus that had some "go" to them and that he would operate before the class. The members of the class would of course not understand the principles underlying all these appliances and therefore the goal of the year's work would set itself, and it would be a goal full of meaning and promise. Who in that class would not look forward with keen anticipation to gaining a rational insight into the working of all these wonderful things?

But the first trip should only be an earnest of more trips to come. The study of every topic, whenever possible, should culminate in one or more trips of this kind, only the aim now should be to observe in a precise way how the various physical principles work and how they are applied. The actual steam engine should now be observed with care so that its operation would become clear, and the motor on the street car should be uncovered and the current traced through from the trolley down to the rails.

It has been my experience in teaching high school physics that all classes of citizens are not only willing but pleased to coöperate with the teacher in bringing the applications of science to the attention and comprehension of students. Doors usually labeled "No Admittance" swing open without difficulty for classes properly guided and with a serious purpose, and the foremen and engineers regard it as a privilege to be of assistance. A physician

with X-ray and other apparatus is usually no less courteous in giving demonstrations, and by a manufacturer the visit of a class may be looked upon as an opportunity. Lack of coöperation outside of school in science teaching can seldom, if ever, be pleaded by the teacher, and even small cities contain many places worth visiting. It is refreshing to see what a new and interesting place a printing office is to a high school class. In botany and zoölogy but little coöperation is needed, for the data of these sciences are free for every one out of doors.

The teaching of a science in this vital way takes time and effort on the part of both teacher and pupils but the motive that it puts back of the work makes it possible to cover more rather than less ground. A student who knows that he is going to have the actual things of life interpreted to him through his study, and that he is going to have them interpreted immediately under the guidance of the teacher, is not likely to dawdle over his textbook and laboratory exercises, but is likely to master them immediately and with enthusiasm. He needs the knowledge he will gain on the very next trip and he needs in a way that will yield him direct satisfaction.

The laboratory work in a course of physics taught in this vital manner, it is evident, should hold a close relation to the work that is being done in the textbook. But this is now not always the case. In many places the laboratory work forms a course quite independent from that based on the textbook, being guided by its own manual and exercises. Many of these exercises look very much like busy work that was invented to keep students occupied. They may be all right from the standpoint of the accomplished scientist, but for the high school student they are too remote from his present needs. They appear to him merely as tasks that have to be ground through.

The primary function of laboratory work in high school physics should be to bring the work one step nearer the real than is done by the textbook. The members of the class should verify and apply the principles that are being studied in class and they should not be asked to do this in too precise a fashion. The quantitative aspect of physics, while properly placed foremost in the college, should hold a distinctively secondary place in the high school. Here the qualitative aspects belong foremost. The high school student needs an abundance of experience with the phenomena and applications of science, and only after he has these can he be expected to show an interest in precise investigations and the

mathematical framework. These things have no meaning for the beginner and belong to the advanced scholar and specialist. We have, however, been trying to begin with them and as a result our students are not interested and often positively dislike the work.

Let the high school teacher therefore make his work real; let him go to the trouble of making the phenomena and applications of science as these are actually going on out in the world an integral part of his class work; let him make these phenomena and applications his highest objective point and let him introduce his classes directly to them. His work will then not only be interesting, but, in the highest degree, educative.

A TRAVELING HOSPITAL FOR RURAL NEEDS.

A pressing need of our rural districts is for the same kind of hospital treatment which is open to even the poorest inhabitants of our city slums. Dr. C. W. Stiles has made some observations on this subject as a part of his work with the Hookworm Commission. The average mother with whom he comes in contact in field work is attended in her confinements, rarely by a physician or a trained nurse, usually by some of the neighbors or a dirty and ignorant midwife, with the result that injuries frequently occur which are never properly treated. He also finds large numbers of children who are handicapped in their physical and mental development by large tonsils and adenoids, and by defective eyes and teeth. He says, moreover, that the average country woman (white or black) with whom he comes in contact has exceedingly rudimentary ideas on cooking, housekeeping and care of children and the sick, and to meet the needs of this side of the problem the district nurse would be invaluable. The remedy which he proposes for these evils is a traveling hospital, equipped for the minor surgical work on children suggested above and for the repair of obstetric injuries or gynecologic ailments. He believes that it would be a comparatively simple matter to fit out a special hospital train of from three to six cars and take it to districts without hospitals. The difficulties to be overcome in establishing these trains are not insurmountable, and the expense need not be greater than that connected with any other hospital. The traveling hospital could also be utilized to bring about such results as much-needed postgraduate medical instruction to local physicians; ideas on cooking, housekeeping, infant-feeding, etc., to mothers; ideas on sanitation to the fathers, and special instruction along health lines to the schools. Stiles believes that this work is more important than the teaching of the farmers by special school trains how to increase their crops or how to take care of their live stock. *The Journal of the American Medical Association,* commenting on Stiles' experience, says that the suggestion is the more valuable coming from Stiles, as he has had practical experience on laboratory trains in the rural districts in which research and observations were conducted on school children. This has shown him the need, the practicability and the possibilities of such a hospital train as he suggests.

THE NEGATION OF PERPETUAL MOTION IN ELEMENTARY PHYSICS.

By Wilson C. Morris,

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Since the term perpetual motion is to be used repeatedly, let us in the beginning assign a meaning to it. Some who meet this term for the first time are inclined to interpret it very literally—moving for ever. As in other phases different persons will assign different meanings. The student of physics generally understands a perpetual motion machine to be one that will do useful work without drawing on an external source. It is a machine in which the output is greater than the input; or finally, it is one that will create energy. In this paper I shall *not* deal with perpetual motion of the second sort, as it is now generally conceded that the second law of thermodynamics is not rigorously true under *all* conditions.

The first recorded attempts at perpetual motion are relatively recent, historically speaking. Probably they do not date back of the thirteenth centry. Perpetual motion then is one of the newer "follies of science"; for those familiar with the history of mathematics know that the quadrature of the circle engaged the attention of many of the most noted early geometricians.

One of the earliest recorded attempts at perpetual motion is by Peter Peregrinus, who lived about the middle of the thirteenth century. His name is sometimes associated with that of Roger Bacon, the greatest scientist of the middle ages. Peter Peregrinus being familiar with the magnet and the magnetic attraction designed a perpetual motion machine based on the principle of magnetic attraction. He was wiser than most perpetual motionists for he stopped with the designing and left the task of carrying out the design to another party. For an account of his work the reader is referred to Benjamin's "The Intellectual Rise in Electricity."

It is no part of my purpose to write the history of perpetual motion nor to enumerate and describe the various contrivances designed and constructed for the purpose of effecting it.[1] Neither is it my purpose to condemn those who wish to try their hand at it; but I would give a friendly warning to those not familiar with the history of the subject that the accomplishment of such a task is opposed by what has been learned in the hard school of

[1]See Phin's Seven Follies of Science.

experience for the past six hundred years. Personally I do not deplore all the effort as wasted for negative values in experiments have their place. All this experience helps to place one of the greatest generalization in physical science—the principle of the conservation of energy—on a rock bottom foundation; or as Preston put it[2]: "The alchemists in chemistry have been somewhat like the perpetual motionists in natural philosophy. Both, by seeking after the impossible, have led up to discoveries of the greatest importance and practical value."

One of the first men to grasp the idea that perpetual motion is at variance with our experience was Stevinus. This is set forth in his work on the mechanical properties of the inclined plane, published near the close of the sixteenth century. He supposed a flexible endless cord of uniform density on which are strung fourteen balls of equal mass at equal distances apart to hang on a triangular-shaped support composed of two unequally inclined planes with a common horizontal base. (See figure 1.)

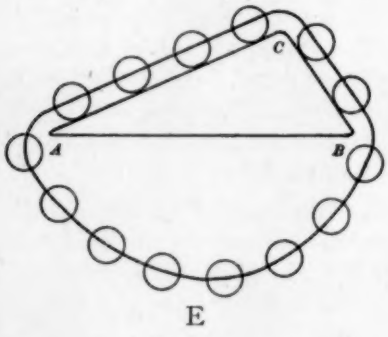

FIG. 1.

Let the part AEB contain eight balls; and for the sake of simplicity take AC = 2BC. He is investigating the condition for equilibrium; hence but one of two things can happen, the balls will be in equilibrium when so arranged or they will not. If they are not in equilibrium, motion will ensue; but this motion cannot change the condition of affairs as there will always be eight balls in the part AEB, four on AC and two on BC; hence once the system starts to move it must continue; that is, there will be perpetual motion, a thing he was not only unwilling to accept but deemed it wholly improbable. He also shows that the

[2]See "Theory of Heat," p. 7.

equilibrium conditions are not disturbed by removing the eight balls in AEB; since, from the arrangement, the four balls on AE oppose the four on EB. Hence the four balls on the longer inclined plane balance the two on the shorter plane or the weights would be as the lengths of the planes intercepted by the horizontal plane AB. If we take CB vertical (see figure 2) we have but one inclined plane and the condition for equilibrium follows at once.

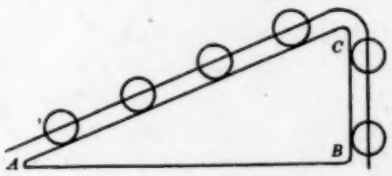

FIG. 2.

We have found that the weights are as the lengths; that is, $4 : 2 = AC : BC$. If we call the two balls the acting force and the four balls the resisting force; then it follows, that the resisting force : acting force = length : height, the well known condition for equilibrium on the inclined plane when the acting force is parallel to the inclined plane.

Concerning the work of Stevinus Mach[3] has the following to say: "Unquestionably in the assumption from which Stevinus starts, that the endless chain does not move, there is contained primarily only a *purely* instinctive cognition. He feels at once, and we with him, that we have never observed anything like a motion of the kind referred to, that a thing of such a character does not exist. This conviction has so much logical cogency that we accept the conclusion drawn from it respecting the law of equilibrium." Again on page 29 of the same work he continues: "The reasoning of Stevinus impresses us as so highly ingenious because the result at which he arrives apparently contains more than the assumption from which he starts." For a good critique of the work of Stevinus the reader is referred to Mach's Mechanics.

The next man who saw clearly the unreality of perpetual motion was Galileo in his work of comparing the motion of a body on an inclined plane with that of a body falling freely. Take the inclined plane AB (figure 3).

[3]See McCormack's translation of Mach's "Mechanics," p. 26.

He assumed the velocity gained in moving from A to B (friction neglected) is the same as the velocity gained in falling freely

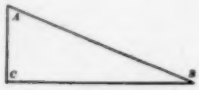

FIG. 3.

from A to C. If this be not so, by following Galileo's argument we can show that bodies will rise by reason of their weight.

A body starting from rest at A will reach C in some time as t seconds with a velocity V; and this velocity as proved by Galileo has increased proportionally to the time. If now we reverse the motion and let it leave C with a velocity V it will reach A in t seconds (the time required to fall from A to C); and its velocity at the end of this period will be zero. Likewise if it start from rest at A it will reach B in t' seconds with some velocity as V′. If now we reverse the direction and let it leave B with a velocity V′, in t' seconds it will reach A, and will have no velocity; hence we may make three assumptions V is equal to V′, V is greater than V′, or V is less than V′. Let us suppose that the second or the third assumption is the correct one; then we shall let the body fall along the path in which it gains the greatest velocity, and rise along the one in which it loses the least velocity; and hence a body of its own accord will rise to a greater vertical height than that from which it fell; for it will neither gain nor lose velocity along the horizontal path BC or CB as we are dealing with the force of gravity only; but that a body will rise to a greater vertical height than that from which it fell is at variance with experience. Hence only the first condition can be true. If the second or third be true, perpetual motion is possible. Galileo was not satisfied with the mere philosophical discussion of the problem, but being an experimenter of the first rank he proceeded to test his conclusion by experiment. He fastened one end of a flexible string to a nail driven in the wall and from the other he suspended a heavy ball.

Lifting the pendulum (see figure 4) from M to A (keeping the string elongated) and letting it go, he found it rose to about the same height on the other side. Any shortage he attributed to air resistance. Now he varied the experiment by driving a nail in the wall at X to the right of the string while it hangs vertically. The ball will now describe the arc AM; but when the string strikes

the nail X, the part CX will not move, and the ball will describe the arc MK. He now inserts a nail at Y and the path described is A M G. In each case the ball rises to the same level; hence the *inclination* of the plane has no influence on the velocity. While the velocity gained in falling from A to C (figure 3) is the same as that gained in moving from A to B, it does not *follow* that the time required from A to B is the same as that required from A to C.

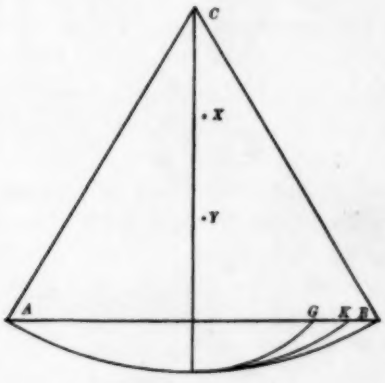

FIG. 4.

As to whether Newton grasped the idea of the impossibility of perpetual motion there is some doubt. In his work in celestial mechanics, the idea of central force is the all important factor. The idea of work and energy plays a small role in the *Principia.* In the scholium to third law of motion he enunciates the following principle: The work done by the acting agent is the work done against the resisting agent. The step from this to the conservation of energy is but a small one.

Regarding Newton's ideas on perpetual motion Mann in his "Teaching of Physics" has the following to say: "It is difficult to conceive that Newton did not perceive that perpetual motion is impossible, especially since Galileo and Huygens had already made such fruitful use of the intuition. It seems far more probable that he did perceive it, but did not mention the fact, because, with the science of heat still in the intuitive stage, he could not treat it in the same rigorous way in which he treated the other mechanical relations, action and reaction, for instance."

The same fruitful principle which guided Galileo in the study of velocities down inclined planes of the same vertical heights but

different slopes served to guide Huygens in dealing with the time of swing of a compound pendulum. Imagine the pendulum at the moment when it is passing through its lowest position to be freed from molecular forces and to be resolved into separate particles each continuing in motion as a simple pendulum by reason of inertia. The height through which the center of gravity of the system composed of simple pendulums will rise in consequence of the motion is the same as the height to which the center of gravity of the body as a whole would rise. If this were not so, Huygens argued there would be a rise of weights effected by the inherent tendencies of bodies and without the aid of external forces. If the body did not rise to the same height in both cases (when coherent, and when in separate particles) Huygens saw a means of arriving at perpetual motion.

Roget an ardent supporter of the chemical theory of the cell as opposed to Volta's contact theory uses intuitively the principle of negation of perpetual motion. Whittaker in his "History of Ether and Electricity" quotes from Roget's "Galvanism" (published 1832) as follows: "If there could exist a power having the property ascribed to it by the [contact] hypothesis, namely, that of giving continual impulse to a fluid in one constant direction, without being exhausted by its own action, it would differ essentially from all the other known powers in nature. All the powers and sources of motion, with the operation of which we are acquainted, when producing their peculiar effects, are expended in the same proportion as those effects are produced; and hence arises the impossibility of obtaining by their agency a perpetual effect; or, in other words, a perpetual motion. But the electro-motive force ascribed by Volta to the metals when in contact is a force which as long as a free course is allowed to the electricity it sets in motion, is never expended and continues to be exerted with undiminished power, in the production of a never-ceasing effect. Against the truth of such a supposition the probabilities are all but infinite."

This statement which falls little short of the doctrine of the conservation of energy was written a few years before the formal enunciation of the principle of the conservation of energy.

In his celebrated essay on "The Motive Power of Heat" (1824), a paper whose value the world was very slow in recognizing, Carnot, in seeking to establish a relation between the work performed by an engine and the heat drawn from the furnace, based his work on two principles, the negation of perpetual motion and

the conservation of the calorie. The latter principle is now obsolete; but this has little effect on his work for in most of the work on heat it makes little difference in the conclusions whether we take the commonly accepted dynamical theory or the caloric theory which was formerly accepted.

In his later writings (not published until after his death) he seems to have accepted the dynamical theory. It may be that the work of Young and Fresnel or the wave-theory of light had something to do in bringing about the change. That he grasped both the idea of conservation of energy and the dynamical theory of heat is shown by the following (see Preson's "Heat" p. 704): "Heat is simply motive power, or rather motion which has charged form. *It is a movement among the particles of bodies.* Whenever there is a destruction of motive power there is at the same time production of heat in quantity exactly proportional to the quantity of motive power destroyed. Reciprocally whenever there is a production of heat there is destruction of motive power."

"We can then establish the general proposition that motive power is a quantity invariable in nature—that is, correctly speaking, never either produced or destroyed."

About the same time Faraday used the principle of negation of perpetual motion in offering his objections against the contact theory of Volta (see "Experimental Researches" § 2071).

In 1831 Faraday announced his epoch making discovery of electromagnetic induction. Three years later the Russian physicist Lenz announced the law so well known by his name. One phase of this law may be stated thus: When a conducting circuit is moved in a magnetic field the induced current flows in such a direction that the ponderomotive forces on the circuit tend to oppose the motion. Were this not so, it would *not* be necessary to have steam-pressure or falling water to turn the dynamo armature; but since every dynamo *tends* to "motor," a prime mover must be used to overcome the motor drag; and hence the impossibility of perpetual motion in this direction.

If we take apparatus somewhat like that with which Faraday made his famous discovery in electromagnetic induction (a few turns of heavy wire wound on an iron core and connected to a battery and key, and inserted in, and insulated from a secondary coil consisting of a large number of turns of fine wire with the terminals joined to a galvanometer) when we close the key the galvanometer deflects one way and when we open the key it deflects in the opposite way. Lenz's law for this case may be stat-

ed thus: The current induced in any circuit by a varying flux always opposes *changes* of the flux which give rise to it.

This is also a negation of perpetual motion. When we say that the field due to the induced current at "make" opposes the existing field, it is equivalent to saying we can't get a magnetic field without the expenditure of energy. Did it not act this way, perpetual motion would be possible. In the same manner when the circuit is broken in the primary coil, the energy used in producing the magnetic field tends to keep the current flowing; but the time of flow is brief for energy stored is soon used in overcoming electrical resistance.

We have an analogous case in the fly-wheel of an engine. The fly wheel because of its inertia opposes the motion due to steam pressure on the piston until *normal* speed is acquired (resistance neglected). On the other hand when the steam is shut off the fly wheel *tends* to keep the machinery running uniformly until it has dissipated its store of energy in overcoming resistance.

The brief review given has shown that several men had grasped the idea of the absurdity or the impossibility of perpetual motion; but all work to which we have referred dates back to 1840. About 1840, owing to the recent introduction of the steam-engine and the industrial changes brought about thereby, the subject of energy received the attention of many scientists of excellent ability, of whom some of the well known are Joule, Helmholtz, Thomson (Lord Kelvin) and Mayer. It is only after the experimental work of Joule, that the doctrine which teaches the impossibility of the creation or destruction of energy received anything like general acceptance. Today it is one of the corner stones on which the subject is built.

One of the applications of the negation of perpetual motion in elementary physics, is to show that the work done in carrying a body from one height to another against gravity *alone* is independent of the path (this is not true if we take into consideration resistance; but is only true for conservative forces). We have an analogous problem in electricity. If we take an insulated isolated body with a positive charge and bring another *small* positively charged body (it makes no difference about the sign of the charge but positive has been selected to give a repulsion and thereby differ from gravity which is always an attraction) into the field of the first charge; then it will follow from the negation of perpetual motion that the work done in moving the small charge from one point to another nearer the first charge is independent of the shape of the path.

To the student whose training in mathematical physics enables him to grasp the idea of the potential, and that the potential at any point is a function of the coördinates of that point, it is at once evident that the work done depends only upon the initial and final positions and not upon the shape of the path. Readers familiar with the elements of thermodynamics know that when heat is applied to a body, part will be spent in doing external work and part in altering the internal energy of a body; or if the quantity of heat added is $d\,Q$, if the external work done is $d\,W$, and the change in internal energy is $d\,U$, then we can express the above algebraically thus: $d\,Q = d\,U + d\,W$.

The change in internal energy depends only upon the initial and final state; and is independent of the shape of the path along which we assume the change to take place. In other words U (the internal energy) at any point is a singled-valued function of the coördinates of the point, or $d\,U$ is an exact differential. To readers who are far enough along to interpret complete or exact differentials physically, the above is at once evident; but these methods are not for use in elementary physics.

Let us take a concrete problem for gravitational force and one for electrical force; and show that the work done is independent of the path by negating perpetual motion.

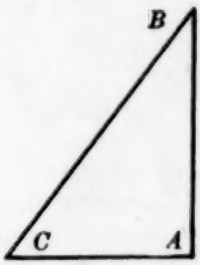

FIGURE 5.

"A man carries a load up a vertical ladder AB (figure 5); at another time he carries the same load along the inclined ladder CB; in which case did he do more work?" Since we are dealing with gravitational force no work is done in passing from C to A or from A to C, since CA is a horizontal line and no work is done by or against a force when its direction is at right angles to the direction of motion.

Suppose W_1 units of work are done in moving a body from A

to B and W_2 in moving the same body C to B, and suppose that W_2 is greater than W_1; now let the body be moved around the cycle ABCA (in a counter-clock wise direction). From A to B work must be done against gravity equal to W_1 units; but in passing from B to C gravity does work equal to W_2 units. From C to A no work is done by or against gravity; hence when the cycle has been completed, there is an excess of energy equal to $W_2—W_1$; but this leads to perpetual motion. In just the same way it can be proved that W_2 is not less than W_1. Therefore W_2 and W_1 are equal.

One of the hard problems the teacher of elementary physics has to face is to get a student to see that if a galvanometer is shunted by a coil of wire the fall of potential through the coil is the same as the fall through the galvanometer. This at once follows from the fact that the fall of potential is independent of the path. Take an insulated isolated body with a positive charge and bring a unit positive charge into its field (see figure 6).

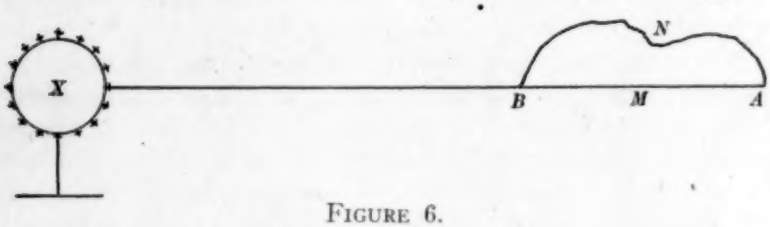

FIGURE 6.

Let A be a point at which a unit positive charge is initially placed; and let it be at a great distance from X (the charged body). Then the potential at B is the work done in carrying the unit charge from A to B. Suppose the work done in carrying it along the path AMB is W_1, and in carrying it along ANB is W_2, and suppose W_2 is greater than W_1. In moving the unit positive charge along AMB work must be done against the electrical repulsion of X equal to W_1 units; and in moving along the path BNA the electrical repulsion of X does work upon the charge equal to W_2 units; hence if W_2 is greater than W_1 when the charge moves around the circle in a clockwise direction there will be an excess of energy equal to $W_2—W_1$. Hence if we repeat the process indefinitely an indefinite amount of energy can be gained; or perpetual motion is possible; but this is at variance with experience; hence the drop in potential along the branch BNA is the same as the drop along BMA; or the fall through the gal-

vanometer, although its resistance may be hundreds of ohms, is the same as the fall through the shunt-coil which may have a resistance of only a few ohms.

I think I am able to forecast what some of the readers of this article will say. It will be somewhat as follows: "This method in physics is very good if you are preparing students for work on Carnot cycles and allied problems; but what percentage of our first and second year students will need to know methods applicable to Carnot cycles?" In answer to this let me say that I have just finished reading rather carefully Mann's "Teaching of Physics"; and, if I had previously held the view that elementary physics is a gauntlet to be run for university entrance, or that special methods must be employed in elementary physics so that a few may acquit themselves well when they come to post graduate physics, I surely would hold them no longer after reading this book. I hope I may not be accused of advocating the methods of post graduate physics for elementary physics; but here is a principle (the negation of perpetual motion) that, while it applies to advanced physics (generally known there as the principle of the conservation of energy), it is so simple that it may be used effectively in elementary physics. In my own classes in the Normal School, both in the first year and second year, I make considerable use of it; and I have little trouble with the students in dealing with work problems involving vertical heights and inclines, induced currents, relation of motors and dynamos and various other problems to which this principle lends a simple solution.

PHILIPPINE SULPHUR.

In the Philippines, as in Japan, sulphur is found in connection with extinct or dying volcanoes. In places, one encounters small cones of nearly pure sulphur built up around vents from which have issued, and in some cases still issue, sulphurous gases. Sulphur is also found permeating the volcanic rocks in the neighborhood of these vents. It is quite possible that boring in and about volcanic regions in the Philippines will disclose important quantities of sulphur-permeated rock. When the sulphur content is not less than 8 or 10 per cent, such material can be worked profitably where labor and transportation conditions are favorable. We have no estimates of the quantity of sulphur available, except in the case of the Biliran island and Leyte deposits. Goodman, formerly of the Philippine Bureau of Science, estimated that there were possibly 3,000 tons in the three deposits in sight. Of the amount on the island of Camiguin (north of Luzon), Ferguson, formerly of the Bureau of Science, could give no estimate, but reported that there was apparently a commercial deposit.

THE RULE OF BIOCHE AND ITS APPLICATION TO THE SOLUTION OF TRIGONOMETRIC EQUATIONS.

By A. Babbitt,
Student of Pennsylvania State College.

The rule of Bioche states that if the signs of the terms of a trigonometric equation are not changed when the argument of the function is changed from x to $\pi+x$ or to $\pi-x$, or to $-x$ then all the terms of the equation can be expressed rationally in functions of tan x only (in the first case), or in functions of sin x only (in the second case), or in functions of cos x only (in the third case), since only $\tan(\pi+x) = \tan x$, $\sin(\pi-x) = \sin x$, and $\cos(-x) = \cos x$.

From the preceding rule of Bioche, which I met a few years ago in a French magazine of elementary mathematics, it appears at once that if the substitution of $\pi+x$ or of $\pi-x$, or of $-x$ into a given trigonometric equation instead of x does not produce any change in signs, then all the terms of the equation can be expressed respectively in functions of tan x, sin x or cos x.

We will now illustrate how the rule can be applied to the solution of trigonometric equations. Let us consider the equation

$$\sec x = \sin x + \cos x$$

Substituting $\pi+x$ for x, we obtain,

$$\sec(\pi+x) = \sin(\pi+x) + \cos(\pi+x), \text{ or}$$
$$-\sec x = -\sin x + (-\cos x), \text{ or}$$
$$\sec x = \sin x + \cos x.$$

Therefore, according to the rule all terms of the given equation can be expressed rationally in functions of $\tan x$ only.

Multiplying through the given equation by $\sec x$, we obtain,

$$\sec^2 x = \sin x \sec x + \cos x \sec x, \text{ or}$$
$$1+\tan^2 x = \tan x + 1, \text{ whence}$$
$$\tan^2 x - \tan x = 0. \text{ Solving this equation we find}$$
$$x = k\pi, \text{ or } k\pi + \pi/4. \text{ (When } k \text{ denotes any positive or negative integer.)}$$

As a second illustration let us consider the equation,

$$\tan x = \sin x \cos x.$$

Making the substitution $\pi+x$ for x, we obtain,

$$\tan(\pi+x) = \sin(\pi+x)\cos(\pi+x), \text{ or}$$
$$\tan x = (-\sin x)(-\cos x), \text{ or}$$

$\tan x = \sin x \cos x$.

The terms of the given equation can be expressed in functions of $\tan x$ only.

Dividing through the given equation by $\cos^2 x$, provided $\cos^1 x \pm 0$, we get

$\tan x \sec^2 x = \tan x$, or

$\tan x(1+\tan^2 x) = \tan x$, or

$\tan^3 x = 0$. Solving this equation we find,

$x = k\pi$.

Now, let us try the substitution of $\pi - x$ for x. The equation then becomes,

$\tan(\pi - x) = \sin(\pi - x)\cos(\pi - x)$, or

$-\tan x = \sin x(-\cos x)$ or

$\tan x = \sin x \cos x$.

The given equation can be solved by expressing all its terms in functions of $\sin x$ only.

Rewritting the given equation thus,

$\frac{\sin x}{\cos x} = \sin x \cos x$, multiplying through by $\cos x$, provided $\cos x \pm 0$, substituting $1 - \sin^2 x$ for $\cos^2 x$ and making the necessary transformation, we obtain the simple equation,

$\sin^3 x = 0$, the solutions of which are,

$x = k\pi$.

Let us try the substitution of $-x$ for x in the given equation. The equation then becomes,

$\tan(-x) = \sin(-x)\cos(-x)$, or

$-\tan x = -\sin x \cos x$, whence,

$\tan x = \sin x \cos x$.

Hence all the terms of the given equation can be expressed in functions of $\cos x$. Dividing through the given equation by $\sin x$, we obtain the equation,

$1/\cos x = \cos x$, whence,

$\cos^2 x = 1$, hence,

$\cos x = \pm 1$,

$x = k\pi$.

As a third illustration we willl consider the equation,

$\cos x = \sin^2 x - \cos^2 x$.

Trying the substitution of $\pi + x$ for x, we obtain,

$\cos(\pi+x) = \sin^2(\pi+x)-\cos^2(\pi+x)$, or

$-\cos x = \sin^2 x-\cos^2 x$, whence,

$\cos x = -\sin^2 x+\cos^2 x$.

Hence, the terms of the given equation cannot be expressed in functions of $\tan x$.

Trying next the substitution of $\pi-x$ for x, we get,

$\cos(\pi-x) = \sin^2(\pi-x)-\cos^2(\pi-x)$, or

$-\cos x = \sin^2 x-\cos^2 x$, whence,

$\cos x = -\sin^2 x+\cos^2 x$.

Thus, the terms of the given equation cannot be expressed rationally in functions of $\sin x$.

Trying at last the substitution of $-x$ for x, we obtain,

$\cos(-x) = \sin^2(-x)-\cos^2(-x)$, or,

$\cos x = \sin^2 x-\cos^2 x$.

The terms of the given equation can, therefore, be expressed rationally in terms of $\cos x$ only.

The given equation can be rewritten thus,

$\cos x = 1-2\cos^2 x$, or,

$2\cos^2 x+\cos x-1 = 0$. Solving this equation we obtain the solutions,

$x = 2k\pi$,

But $x = 2k\pi$ is invalid and it should be disregarded,

$x = 2k\pi \pm \pi/3$.

It may be mentioned that in some cases this rule fails. For instance, when considering the equation,

$\sec x-\tan x = \sin x+\cos x$.

In such cases however, Delambre's formulas,

$$\sin x = \frac{2\tan\frac{x}{2}}{1+\tan^2\frac{x}{2}}, \cos x = \frac{1-\tan^2\frac{x}{2}}{1+\tan^2\frac{x}{2}}, \tan x = \frac{2\tan\frac{x}{2}}{1-\tan^2\frac{x}{2}}$$

may be helpful.

MOUNT MARCY HIGHEST POINT IN NEW YORK.

The highest point in the State of New York is Mount Marcy, an Adirondack peak which rises 5,344 feet above sea level, according to the United States Geological Survey. The average or mean elevation of the state is estimated at 900 feet.

HIGH SCHOOL PHYSICS IN THE STATE OF INDIANA.[1]

By Earl R. Glenn,
City High School, Bloomington, Indiana.

INTRODUCTORY REMARKS.

Statement of the Outline. Progress in any line of work must result largely from the efforts of the individuals who labor in that particular field. It is one thing to desire merely a change from the customary usage, and quite another to seek for the facts upon which to base cautiously, a definite and permanent improvement. This investigation is the result of a desire to learn the general practise in the teaching of secondary school physics in the state of Indiana. The results are now offered to science instructors, in the hope that the study may contain something of general interest. This article assumes that the reader knows the shortcomings of the questionnaire method and can judge for himself the amount of confidence to place in it. In this case, however, there was no other plan available for obtaining the necessary information. The replies to the questions have been arranged in a tabulated form, and have been analyzed in a manner that reveals, we trust, the actual status of the teaching of high school physics in Indiana for the year 1911 and 1912.

Sources of Material. The data was obtained by correspondence with the superintendents and principals of the state. The physics teachers were expected to answer the questions, but, in some cases, either the superintendent or the principal filled out the blanks. But, even if one takes into consideration these and other possible sources of error, some facts appear significantly important.

General Impressions of Data. There is a wide variation in the teaching of high school physics in the state of Indiana. This appears in the total amount of time devoted to the subject, the length of the laboratory period, and the methods of instruction. Although over sixty per cent are in favor of segregation, there is at present no serious attempt to differentiate the subject matter for boys and girls. It is not the largest and best equipped schools ordinarily that make physics an optional subject. As has been pointed out previously in School Science and Mathematics, schools differ widely in the number of failures in physics. The lecture demonstration is not in general use in this state.

[1]This report is a portion of a more extensive study now in progress. The work was begun under the supervision of the School of Education of Indiana University.

Although the present text-books are better adapted to boys than to girls, no substantial modification in the subject matter is desired.

COLLECTION OF DATA.

The list of questions, which will be given later, was sent to sixty-five superintendents of the larger *commissioned* high schools in the state of Indiana, late in the spring of 1912. Thirty-two replies were received. Again in the fall of 1912, thirty letters were mailed to the principals over the state and twenty-seven answers were returned. All of these reports are given in the accompanying table of data, as nearly verbatim as space will permit. It was necessary in certain instances (the question mark indicates that) to eliminate shades of meaning or extreme exceptions, but every effort has been made to exclude personal equations. It must be said, however, that in a few cases the reader might secure a slightly different interpretation from that of the author, if the entire reply were recorded.

Every high school in this list is *accredited* by the North Central Association of Colleges and Secondary Schools,[2] except schools numbered 1, 6, 13, 17, 18, 22, 23, 25, 26, and 27. It is interesting to note in this connection that whereas the state of Indiana has fifty-four high schools that are members of the North Central Association of Colleges and Secondary Schools; Michigan has eighty-five; Ohio has one hundred and thirty-one; and Illinois has one hundred and thirty-three.

ANALYSIS OF RESULTS[3].

1. In which year is physics given?
   (a) Fourth year, 52 per cent.
   (b) Third year, 30 per cent.
   (c) Third and fourth years, 12 per cent.
   (d) Two schools did not report.
   (e) One school offers the subject in both the first and third years.

2. Is physics prescribed or optional? (Any choice is regarded as making the subject optional.)
   (a) Prescribed, 35 per cent.
   (b) Optional, 61 per cent.
   (c) Two schools failed to answer this question.

[2]List of schools accredited by the North Central Association of Colleges and Secondary Schools (Adopted March 22, 1912).

[3]The percentages are calculated either on the basis of fifty-nine schools, or on the number of schools reporting upon the particular question.

Name of the High School	Number of School	Physics, Year Given	Prescribed or Optional	Adopted Text
Logansport	1	3	Prescribed	Car. & C., Gorton
Name withdrawn	2	3	Prescribed	Car. & C.
Jeffersonville	3	3	Prescribed	Hoadley
Name withdrawn	4	3	Optional	M. & G.
Name withdrawn	5	3	Optional	Car. & C.
Name withdrawn	6	4	Physics or Chemistry	M. & G.
Bedford	7	4	Physics or Chemistry	Car. & C.
Crawfordsville	8	4	Optional	M. & G.
Connersville	9	4	Optional	Adams
Name withdrawn	10	3	Optional	Adams
La Porte	11	4	Optional	Car. & C.
Wabash	12	3	Optional	Hoadley
Linton	13	4	Optional	M. & G.
Hammond	14	4	Optional	M. & G.
Frankfort	15	4	Physics or Chemistry	Hoadley
Wiley H. S., Terre Haute	16	3 & 4	Optional	Car. & C.
Marion	17	3	Optional	M. & G.
Vincennes	18	4	Prescribed	Mumper
Michigan City	19	4	Prescribed	Car. & C.
Franklin	20	Physics not	offered in this high school	
Attica	21	4	Prescribed	M. & G.
Rockport	22	4	Prescribed	Hoadley
Princeton	23	4	Prescribed	M. & G.
Whiting	24		Prescribed	M. & G.
Delphi	25	4	Prescribed	M. & G.
Monticello	26	4	Prescribed	M. & G.
Greencastle	27	4	Prescribed	M. & G.
Goshen	28	3 & 4		M. & G.
Mt. Vernon	29	4	Optional	Hoadley
Kokomo	30	3	Optional	M. & G.
Rushville	31	4	Prescribed	M. & G.
Richmond	32	3	Prescribed	Gorton
Name withdrawn	33	3	Optional with girls	Hoadley
Rensselaer	34	3	Optional	Gorton
Brazil	35	4	Optional	Car. & C. (Revised)
Elkhart	36	3	Prescribed	Linebarger
Indianapolis (Shortridge)	37	3 & 4	Optional	Gorton (M. & G., Car. & C.)
Mishawaka	38	4	Prescribed in some courses	Car. & C.
Name withdrawn	39	3 & 4	Optional	M. & G.
Union City	40	4	Optional	M. & G.
Evansville	41	4	Optional	Car. & C. (Revised)
Gary	42	1 & 3	Optional	Gorton
Lafayette	43	3	Prescribed	Hoadley
Elwood	44	4	Prescribed	Linebarger
Plymouth	45	4	Optional	Adams
Name withdrawn	46	4	Optional	Car. & C.
Sheridan	47	4	Optional	M. & G.
Sullivan	48	3	Optional	Hoadley Brief C.
East Chicago	49	3	Optional	Mann & Twiss
North Manchester	50	3 or 4	Optional	Car. & C. (Revised)
Huntington	51	3 & 4	Optional	Linebarger
Anderson	52	3	Optional	Hoadley
Shelbyville	53	4	Prescribed	M. & G.
Hartford City	54	4	Optional	Car. & C. (Revised)
Lagrange	55	4	Optional	M. & G.
Columbus	56	4	Optional	Car. & C.
Lebanon	57	3 & 4	Prescribed	M. & G.
Culver Military Academy	58	3	Prescribed	M. & G.
Bloomington	59	4	Prescribed	M. & G.

*4% to 6% fail in year's work. 10% to 15% fail in part of the work.

Name of Bound Manual	Experiments, Various Texts	Written Directions	Typewritten Experiments	Other Methods	No. Oral Discussions per Class Each Week	
		Yes	Yes		3	
Chute	Yes			Oral directions	5	
	Yes				3 & 4	
M. & G.		Yes	Yes		4	
Chute	Yes	Yes	Yes		Average 2½	
M. & G.					3	
Loose leaf manual					3	
M. & G.					1	
Adams	Yes	Yes	Yes		2 & 3	
Chute	Yes	Yes			3	
M. & G.					3	
			Yes		3	
M. & G.	Yes				3	
M. & G.					2	
Hoadley	Yes				5	
Atk., Mentzer & Grover					5	
M. & G.	Yes				3	
None	None	None	None	None	5	
Chute					5	
M. & G.	Yes	Yes	No		3	
Use own text	Yes		Yes		5	
None	Yes	Yes	No		4	
M. & G.	Yes	Yes			2	
	Yes	Yes	Yes	Yes	5	
					5	
	A few	Yes	Yes		1 to 3	
M. & G.					3	
	Yes	Yes	Yes	Loose leaf notebook	2	
	Yes	Yes	No		3	
M. & G.	Yes	Yes	No		3	
None	No	Yes	Yes		6	
Carter					Not regular	
	Yes	Yes			5	
	Yes		Yes		3	
	M. & G., Chute		Yes		2 & 3, Double periods	
	Yes		Yes		3	
M. & G.	Yes				3	
M. & G.	Yes				3	
M. & G.	Yes	Yes	Yes		3	
Chute	Yes	Yes			3	
			Yes		3	
Linebarger					5	
Adams					2 & 3	
None	Yes	Yes	Yes		3 & 4	
M. & G.	Yes	Yes			3	
Hoadley	Yes	No	No	Original suggestion	3	
Coleman	Yes		Yes		2	
	Yes	Yes			4	
Linebarger		Yes		Optional experiments	3	
Hoadley	Yes	Yes	Yes		3	
M. & G.			Yes		2 & 3	
Loose leaf manual					3	
M. & G.	Yes	Yes			3	
	Yes	Yes	No	None	4	
M. & G.	Yes	Yes			3	
M. & G.					3	
M. & G.	Coleman, Adams Hoadley, Linebarger	Yes	Yes	Oral directions	At least 3	

Discussions Each Week	Length of Period	No. Lab. Periods per Class Each Week	Length of Lab. Period	Total No. Minutes Each Week	Is the Lecture Demonstration a Success With High School Students?	Do all Students work on the Same Experiment at the Same Time?	Do You Favor the Plan of Different Experiments at the Same Period?	Do Yo Boys a Diff Cour Phy
3	40	2	80	280	No	Yes	Good work may be done this way	No
5	40	Average 2½	40	300	No (?)	No	No	No
& 4	40	1 & 2	Varies	200 (?)	No	No	Yes	No
4	30	7	42	420	With elective students	As much as possible	No	No
ge 2½	40	2	80	260	No	No	Yes	No
3	80	2	80	400	Yes	No	Yes	No
3	40	2	80	400	To a limited extent	No	Yes	No
1	40	4	80	360	Yes, under the present condition	Yes	No	No
& 3	40	2	85	315	Yes, as used	No	Yes (?)	To a lim extent
3	45	2	90	315	No	No	Yes	No
3	45	2	90	315	No	Two sets	No	No
3	40	2	80	280	No	Yes	Yes	No
3	40	2	80	280	No	No	Yes	No
2	45	2 (?)	90 (?)	270	No	No	No	No
5	45	2	90	405	No	No	Yes, for exp. which follow text work	No
5	40	4	40	360	Yes	No	Yes	Girls do physic
3	40	2	85	315	No	Yes	No	No
5	40	None		200	No			No
5	45	5	45	450		No	No	No
3	45	2	90	315	No	No	Yes	No
5	40	1	40	240	No	No	Yes	No
4	40	1	40	400	No	Yes	Yes	No
2	40	4	80	400	Yes	No	Yes	No
5	40	2	40	320	No	Yes	No	No
5	45	2	Varies	225	Yes	No	Yes	No
to 3	40	1 to 3	80	200	Yes	No	No	No
3	45	2	90	315	Yes	No	Yes	No
2	40	3	80	320	Yes, to a certain extent	No	Yes	No
2	40	3	90	350	No	No	Yes	No
3	40	2	80	280	No	No	Yes	No
6	40	3	80	450 (?)	No	No	To a certain extent	No
egular	45	2	45	270	Yes	Yes	No	No
5	45	1	90	315	Yes (?)	No	No	No
3	40	4	40	280	Not regularly	No	Yes	No
	40	About 3	40	225 (?)	Yes	No	No	No
uble periods	90	3 & 2	90	450	No (Not in college style)	No	No	Practica same
3	45	3	45	270	Yes (?)	No	Yes	No
3	40	2	80	280	No	No	Yes	No
3	45	2	90	315	Yes (?)	No	No	No
3	40	2	80	280	No	Yes (?)	No	No
3	85	2	85	450, 144 (½ yr.)	No	No	Yes	(Yes in year)
3	45	2	90	315	To a limited extent	No	Yes	No
5	40	No regular program	40	200	Yes	No	No	Yes
& 3	45	4	45	180	Yes	No	No	No
& 4	45	2 & 1	45	225	Yes	No	Yes	No
3	45	2	45	225	No	Yes	No	No
3	85	2	85	425 (?)		No	Yes	No
2	40	2	90	240	No	No	Yes	(No girl
4	40	5	40	360	No	No	Yes	No
3	44	2	88	308	To a limited extent	No	Yes	No
3	40	2	80	280	Yes (?)	No	Yes	No
& 3	40	2	80	200	Yes	No	Yes	No
3	40	2	80	280	No	No	No	No
3	40	2	80	200	Yes	Yes	No	No
4	40	5	40	360	No	Yes	No	No
3	40	2	80	200	Yes	No	Yes	No
3	45	2	90	315	No	Yes	No	No
east 3	45	2	90	450	No	No	No	No

Do You Favor the Plan of Different Experiments at the Same Period?	Do You Give Boys and Girls Different Courses in Physics?	Would You Segregate the Sexes If Conditions Would Permit?	Total Enrollment in High School	How Many Boys Take Physics?	How Many Girls Take Physics?	Per cent of Failures.	D C
Good work may be done this way	No	Yes	500 (?)	32	51	10-15%	No
No	No	No	155	17	22	10-15%	Give
Yes	No	Yes	264	20	30	5%	No
No	No	Yes	500	35	3	5-8%	Yes
Yes	No	Yes	237	17	2	10%	Yes
Yes	No	No	217	40	40	5%	Yes
Yes	No	Yes	240	17	5	10%	Yes
No	No	Uncertain	363	24	26	5%	Yes
Yes (?)	To a limited extent	Yes	251	9	5	6%	No
Yes	No	Yes	225	15	None	10%	No
No	No	Yes	230 (?)	15	12	10%	Indiv and
Yes	No	Yes	254	11	18	25%	No
Yes	No	Yes	200	10	4	14%	Yes
No	No	Yes	240	10	2	8%	No
Yes, for exp. which follow text work	No	Yes, for first half year	345	22	18	5%	No
Yes	Girls do not take physics	No	1000	32	None	None	Yes
No	No	Yes	550	30	20	10%	No
No	No	Uncertain	331	16	8	None	No
Yes	No	Yes	304			10%	
Yes	No	No	138	10	14	None	Yes
Yes	No	Yes, in physics	165	8	20	No data	No
Yes	No	Yes	219	14	16	6%	Yes
Yes	No	Yes	153	8	None	None	Yes
No	No	No	150	16	15	10%	No
Yes	No	Yes	196	23	3		Yes
No	No	Uncertain	223				
Yes	No	Yes	340	20	12	1%	Yes
Yes	No	Yes	243	21	12	17%	No
Yes	No	Yes	498	30	6	15%	Yes
Yes	No	Yes	217	20	21	5%	No
To a certain extent	No	Yes	630	About 45	About 55	10%	No
No	No	Yes	850	75	70	20%	None
No	No	Yes, with different texts	150	12	3	6.6%, 1912-13	No
Yes	No	No	333	17	13	5 to 10%	
No	No	No	439	25 (?) All graduates	25 (?) All graduates		
No	Practically the same	Not in this school	1900	70	80	10 to 12%	Yes
Yes	No	No	180	15	8	5%	No
Yes	No	No	137	4	0	None	
No	No	Yes	141	14	1	None (?)	
No	No	No	825	35	8	5%	
Yes	(Yes in 9th year) No	Yes	200	40	16	7%	Yes
Yes	No	No (Not in a one year course)	454	25 (?) All graduates	25 (?) All graduates		
No	Yes	No	275	15	15	10%	No
No	No	Uncertain		13	1	10%	
Yes	No	No	205	8	0	None	
No	No	Yes	120	8	12	None	
Yes	No	Yes	217	17	3	25%	Yes
Yes	(No girls)	Yes	126	8	5	None	Yes
Yes	No	Yes	96	8	None	None	
Yes	No	No (?)	304	20	2	10%	
Yes	No	No	470	15	20	None	
Yes	No	Yes	248	21	None	5%	
No	No	No	206	9	13		
No	No	Yes	135	10	2	0% (?)	
No	No	No	417	14	0	10%	Yes
Yes	No	Yes	278	22	8	None	No
No	No	Yes	380 (?)	90	20	None	No
No	No	Yes	425	19	None	4 to 6%, 10 to 15%*	Yes
					32	16%	Yes

of s.	Do You Have a Definite Plan for Caring for Failing Pupils?	Outline the Plan Briefly.	Do You Have a Plan for Caring for Students of Different Ability?	Is There Any Topic Commonly Discussed in High School Texts Which Should be Dropped?	Are There Topics Which Should Be Treated Which Are Not Mentioned in the Present Textbooks?	Is the Average Text Too Difficult?	
						Girls.	Boys.
	No		Weak students do fewer experiments	Topics selected according to the class	Yes, in segregated classes	Yes (?).	(?)
	Give special aid	Meet the students outside of class	Use qualitative experiments	Yes	Yes	Yes	Yes
	No		Not the same standard for all pupils	No	Historical side, practical affairs	No	No
	Yes	Individual attention in laboratory				No	(?)
	Yes	Extra work outside of school	Yes	Yes	Yes	Yes	Yes
	Yes	Give a summer course	No	Yes	No	No	No
	Yes	Condition students and give special work	No	No	No	Yes	No
	Yes	Extra work from teacher	No	No	No	Yes	No
	No						
	No		Yes		No	Yes	No (?)
	Individual attention and extra hours		No	No		Yes	No
	No		No	Omit the subject of Light	No	Yes	No
	Yes		Extra work			Yes	Yes
	No		No	Too much material in most texts		Yes	No
	No		No	Abridge Sp. Gravity, Sound, and Properties of Matter	For boys, strength of materials	No	No
	Yes	Students report at definite periods	Give adv. students more lab. work		Yes		Yes
	No					No	No
	No		No	No	No	Yes	Yes
						No	No
	Yes	Individual attention	Yes	No		No	No
	No		No	Yes	Yes	Yes	Yes
	Yes	Private instruction	No	No		Yes	No
	Yes	Give students another science		No	X-Rays, batteries, and mechanics	Yes	No
	No			No		No	No
	Yes	Average: lab., prob., recitation, exam.	Yes	Depends upon school apparatus	Elementary design	Yes	No
	Yes	Students report at end of day		Hard problems	Practical affairs	Yes	Yes
	No		No	No	No	No	No
	Yes	Extra period at end of day	Yes	Technical subjects	Practical affairs	Yes	Yes
	No	No				Yes	No
	No	None	No	No	Modern applications	Yes	Yes
	None		No		Modern applications	Yes	Yes
				Accelerated motion	No	Yes	Yes
13	No		No	Some parts of Light		Yes	No
		(No rank failures) Extra attention	No		None	No	No
				No	None	No	No
	Yes	On indication of poor work, special atten.	Standard and optional experiments	Extreme technical discussions	Modern applications	No (Proper	No laboratory)
	No			No	Weather maps	No	No
						No	No
						Yes	No
					Practical problems	No	No
	Yes	Night school	Summer vac. school	Static electricity	Modern applications	Yes	No
	No		No	Elec. potential not presented so students can understand it.		No (Newer	No books)
						Yes	Yes
					Modern applications	Yes (?)	No
						No	No
	Yes	Individual attention				Yes	No
	Yes	Extra time				No	No
			Round table discus.	Problems in Electricity and Heat		Yes	Yes
			Extra conf. period			Yes	No
					Modern applications	No	No
					Agricultural Physics	No (?)	No
						Yes	No
						No	No
	Yes	Extra period	No	No		Yes	No
	No				Economic side of physics	Yes	Yes
	No		No	Part of Electricity		Yes	No
5%*	Yes	Students are reported def. on fail. to recite	Yes, extra instructor for this work	No	Qualitative work	No	No
	Yes	Condition student and require extra work	Yes (personal suggestion)	No, if students expect to enter college	Illust. should be drawn from the locality	Yes	No

The average number of students in the schools making physics prescribed is 292. The minimum enrollment is 138 pupils, and the maximum number is 630 students.

1. Average per school, 37 pupils.
2. Minimum per school, 8 pupils.
3. Maximum per school, 100 pupils.
4. Average taking physics as a prescribed subject, 12.6 per cent.
5. Minimum taking physics as a prescribed subject, 5.2 per cent.
6. Maximum taking physics as a prescribed subject, 25.1 per cent.

The average number of pupils in the schools making physics optional is 347. (The average becomes 291 if the two large schools, Nos. 16 and 37, are not taken into consideration. This makes a more accurate comparison.) The minimum enrollment is 96 pupils; the maximum 1600. (In the case above, 850 pupils.)

1. Average per school, 33 pupils.
2. Minimum per school, 4 pupils.
3. Maximum per school, 150 pupils.
4. Average taking physics as elective subject, 9.5 per cent.
5. Minimum taking physics as elective subject, 2.9 per cent.
6. Maximum taking physics as elective subject, 36.9 per cent.

3. What is the name of the adopted text used by the student?

Text.	Schools.	Per cent.
Millikan and Gale	23	39
Carhart and Chute	14	24
Hoadley	9	15
Gorton	4	7
Adams	3	6
Linebarger	3	6
Mumper	1	1.5
Mann & Twiss	1	1.5

4. What is the form of the laboratory instructions?
   (a) Bound manual, 66 per cent.
   (b) Various laboratory manuals, 52 per cent.
   (c) Written directions, 38 per cent.

(d) Two schools give oral directions and one offers optional experiments.

5. How many recitations (oral discussions, not demonstrations by the teacher alone) per week are given for each class?

(a) Average number of recitations per week for one class, 3.2.

(b) Per cent of schools below the average of three recitations per week, 19.6.

(c) Per cent of schools above the average of three recitations per week, 32.

6. What is the length of the recitation period?

(a) Average length, 44.5 minutes.

(b) Minimum length, 30 minutes.

(c) Maximum length, 90 minutes.

7. How many laboratory periods does each class have per week?

Periods per week.	Schools.	Per cent.
One	4	7
Two	38	65
Three	5	8
Four	5	8
Five	3	5
Seven	1	2
No regular program	1	2
No laboratory work	1	2

8. What is the length of the laboratory period?

(a) Length of Period.	Schools.	Per cent.
90 minutes	14	25
88 minutes	1	2
85 minutes	4	7
80 minutes	19	34
45 minutes	6	11
42 minutes	1	2
40 minutes	10	19

(b) The average length of the period for fifty-five schools, 71 minutes.

(c) Thirty-one per cent of the schools giving definite reports have only one period (40 to 45 minutes) for individual laboratory work.

9. Give the total number of periods (45 minutes) per week devoted to the subject of physics by any one student.

NOTE.—The answers to this question have been re-arranged by the author to secure a common basis for comparison. Some reports do not take into consideration the study periods in school. The question was intended to include all time regularly arranged for the study of physics in school.

(a) The average time per week for fifty-eight schools is 308 minutes.

(b) The minimum time per week for the study of physics is 108 minutes.

(c) The maximum time per week for the study of physics is 450 minutes.

10. Is the lecture demonstration a success with high school students?

NOTE.—This question was suggested by Professor Robert A. Millikan's excellent discussion of the *Function of the Lecture Demonstration in Secondary School Physics.*[4]

(a) No, 53 per cent.
(b) Yes, 36 per cent.
(c) Undecided, 11 per cent.

11. Do all students in the laboratory, work on the same experiment at the same time?

(a) No, 75 per cent.
(b) Yes, 21 per cent.

NOTE.—In view of the fact that three-fourths of the schools have more than one experiment in progress during the laboratory period, and one-third of the total number reporting have from forty to forty-five minutes for individual laboratory work, the author would like to suggest this question: How many experiments may and can a teacher supervise properly in the short period of forty-five minutes?

12. Do you favor the plan of having different experiments in progress at the same time?

(a) Yes, 50.8 per cent.
(b) No, 44 per cent.
(c) Undecided, 5.2 per cent.

13. Do you give boys and girls different courses in physics?

(a) No, 96.5 per cent.
(b) Yes, 1.7 per cent.
(c) To a limited extent, 1.7 per cent.

14. Would you segregate the sexes?

(a) No, 31 per cent.
(b) Yes, 62 per cent.
(c) Undecided, 7 per cent.

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[4]Proceedings of the N. E. A., 1908, pages 985-991.

15. What is the total enrollment in the high school?
    (a) Total number of pupils enrolled in fifty-seven high schools, 18,889.
    (b) Average number of pupils per school, 331.
    (c) Minimum enrollment, 91.
    (d) Maximum enrollment, 1,600.
16. How many boys take physics?
    (a) Total number, 1,218 or 6.3 per cent.
    (b) Average per school, 22.
    (c) Minimum per school, 4.
    (d) Maximum per school, 90.
17. How many girls take physics?
    (a) Total number, 772 or 4 per cent.
    (b) Average per school, 14.
    (c) Minimum per school, 0.
    (d) Maximum per school, 80.
18. What is the per cent of failures in physics?
    (a) Minimum, 0 per cent.
    (b) Maximum, 25 per cent.
    (c) Average, 7.3 per cent.

NOTE.—Although there is no direct evidence to prove the fact, the author believes that many of the reports here are estimates.

19. (a) Do you have a definite plan of caring for failing students?
    (b) Outline the plan briefly.
    (c) Do you have a plan for caring for students of different ability?

The reader will recognize the important relation of these questions to the subject of high school physics.

It is important to provide opportunity for the student of exceptional ability and to help the pupil who fails. No attempt will be made to classify these replies, but we hope that the reader will refer to the accompanying table and examine the reports from the various schools.

20. (a) Is there any topic discussed in high school texts which you feel should be dropped?
    (b) In the light of your experience as an instructor in physics are there subjects not mentioned in the present day text-books that should be treated?

These questions require time and thought for satisfactory answers. Although only a few schools took the trouble to make a detailed report, the reader, by referring to the table of data, will

find several suggestions that give some light on the general trend of thought along this particular line.

21. Is the average text-book too difficult?

(a) For girls, yes, 60.7 per cent; no, 39.2 per cent.

(b) For boys, yes, 24.5 per cent; no, 71.9 per cent; undecided, 3.5 per cent.

UNCLASSIFIED COMMENTS FROM REPORTS.

1. "Boys and girls need a different text. They don't get brawn of brain with a diet of pie."
2. "Physics is hard for some pupils because in their experience they have not the knowledge with which to begin."
3. "Failures in physics are failures in other subjects as well."
4. "Rapid workers should not be held back."
5. "I find so much material in the average text that I select the very essential and practical, emphasizing the latter."
6. "Prefer all pupils at once on experiments which develop the subject."
7. "If a pupil cannot do the work we advise him to take up work in some other subject. If he can do anything near passing work, we give him special work and pass him.—We accept thirty-three credits in any line of work done enabling the pupil to do what he is able and in the subjects in which he is best fitted."
8. "Text-books are often written to sell and not to instruct."
9. "I think that a large amount of so-called 'technical part' of physics should be dropped, and the subject be more closely related to the life of the pupil."
10. "Some texts are too long."
11. "If you stay with the text, the girls usually prepare better lessons than the boys. It is only when the text is laid aside, if at any time, that the boys are superior to the girls."
12. "I never use all of any physics text and always supplement by much outside matter."
13. "The number of students electing physics is increasing faster than the growth of the school."
14. "I do not assign all experiments to all pupils. I have a definite number of standard experiments but beyond this I give fewer and more difficult experiments to the stronger."
15. "It would be an excellent thing if more adaptation of principles of physics could be emphasized.—I now have to supplement the average text."
16. "I have too much work to give very much attention to failing students."
17. "Most text-books would be improved, in my opinion, by a closer and more frequent application of the principles to practical experience, particularly in the problems."
18. "In the eleventh year we cover the subjects dealt with by the text and require forty experiments to be prepared and written up in neat form. Those who have not been able to complete the experiments have their credit deferred until they complete the work in night school, or in the summer continuation school."
19. "If the failure is the result of not studying, I waste no time with them as it is useless to explain to students who do not study."
20. "Nearly all the old style books are too difficult."

21. "I meet with the students about a table in the period following the close of school and study the next lesson with them."
22. "Have begun to think of a course in agricultural physics."
23. "We do not give formal lectures, but a combination of recitation and demonstration. Lecture method, in our opinion, may give information but not training and should be employed sparingly, if at all."
24. "In a Cleveland high school the average standing of the girls in physics for a period of ten years was higher than that of the boys for the same period."

SUMMARY.

The original purpose of this investigation was to secure facts concerning the present status of high school physics in the state of Indiana for the year 1911 and 1912. In the progress of the work, the following points have been developed: (1) Fifty-two per cent of the schools offer physics in the fourth year; sixty-one per cent of the schools reporting make physics optional; and thirty-five per cent require physics for graduation. There is very little difference in the enrollment of the schools making physics optional and those requiring the subject for graduation, and only a small variation in the number of pupils studying physics,—approximately 10 per cent for the former and something less than 13 per cent for the latter. (The question might be raised,—from considerations of *efficiency* how many elective courses can a high school offer?)

(2) The laboratory instruction is not as well organized as the text-book work. More effective business organization of the individual laboratory work is desirable. Supervisors might easily increase the efficiency of science instruction by requiring a complete yearly invoice of the equipment and a list of all experiments performed by the pupils, with the apparatus for each exercise. The results of all quantitative experiments might also be recorded in permanent form. (3) The most desirable allotment of time for the study of physics is three recitations of forty-five minutes each and two laboratory periods of ninety minutes each. Approximately one-third of the schools do not use this plan. Thirty-one per cent of the schools have periods of forty to forty-five minutes in length for individual experimental work. (4) The average time per week spent on the subject of physics is 308 minutes.

Thirty-six per cent of the schools report the lecture demonstration a success with high school pupils. (5) Three-fourths of the schools have more than one experiment in progress during the laboratory period. (6) Fifty per cent of the instructors

prefer to have various experiments in progress simultaneously. (7) Ninety-six per cent of the schools *do not differentiate* the work for boys and girls. Sixty-two per cent would segregate the pupils in the subject of physics. (8) An average "large" high school in Indiana has an enrollment of 300 to 400 pupils. (9) Six per cent of the boys (calculated on the total enrollment) and four per cent of the girls study physics. (10) There is probably no general attempt to keep a regular and definite record of failures in this subject. The average number of students failing in physics is seven per cent.

(11) No general plan to care for failing pupils or to advance those of exceptional ability is in use in the state of Indiana. (12) Sixty per cent report that the average text-book is too difficult for girls and twenty-five per cent indicate that the standard texts are too difficult for boys. (13) This report does not include approximately 500 smaller *commissioned* and *certified* high schools and about 200 *non-certified* high schools, the majority of which have physics in their curricula.

The subject of physics in the great majority of high schools in the state of Indiana might lend itself to modification along agricultural and industrial lines. This might be desirable in view of the fact that a small per cent of the schools have sufficient equipment and enough properly trained teachers to give efficient instruction in the *pure science* of the average text-book.

Facts of interest and importance to science instruction could be obtained if one of the teachers' associations or any other educational organization of the state of Indiana, would secure information from 100 of the larger high schools on the number of classes the day per instructor, the number of pupils in each class, the number of recitations other than science per teacher, the scientific training of the teacher both in high school, college and university, and the number of years of experience in high-school teaching, etc., etc.

THE AGE OF COAL.

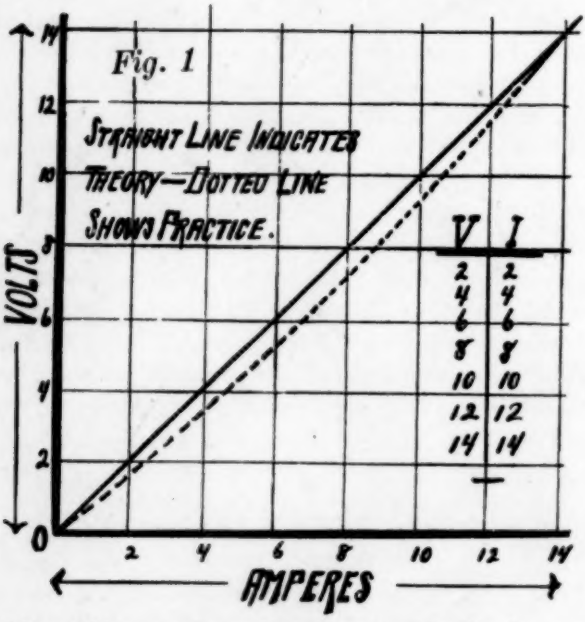
Dr. Marie Stopes of London has been interested for nine years in the study of fossil botany, and has in preparation a book that is expected to throw new light on the subject of coal geology. She has visited the interiors of mines in all parts of the world, including a mine in one of the Japanese islands extending out under the sea. She says coal cannot be less than 20,000,000 years old, and that the first plants which entered into its formation were twice as old as that.

OSCILLATIONS FROM THE ELECTRIC ARC.[1]

By Charles F. Bowen,
Electrical Engineer, Manchester, N. H.

In attempting a consideration of the manifold phenomena presented in the ever-wonderful book of Nature, one is interested at times to observe actions or processes seemingly at variance with established rules and theories. In some cases it is not difficult to stretch the existing theory so as to make it include the unusual behavior but, in others, it is necessary to resort to an entirely new hypothesis. Thus, we have the anomalous expansion of water, of rubber, the phenomenon of diamagnetism and many other instances of equal importance.

Among these other phenomena is that of the peculiar conduct of the direct current electric arc under certain conditions. So unusual is its deportment, indeed, that scientific minds have wrestled with the problem for years without arriving at a satisfactory explanation of what actually occurs. It will be interesting to

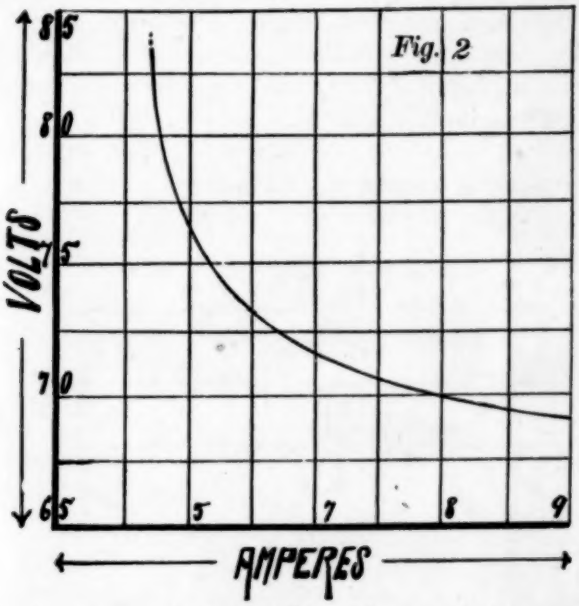


discuss this problem at some length, not only for its own sake,

[1]The following discussion of the electric arc as an oscillator was delivered as a lecture before the Manchester Radio club, Manchester, N. H. While too technical to be treated at similar length even in high school work, the outline of the subject may prove useful to some teacher who desires to dip into the subject so as to be able to explain the phenomenon in a physics class or to some one who may be interested to take up the experimental end of the matter.

but also because of its application to radiotelephony, as a means of producing the undamped waves which are the basis of the methods at present in use.

Suppose, in the case of an ordinary copper wire, we measure the number of amperes passing through it when various voltages are applied at its ends. If this were done and an ammeter and voltmeter properly connected in the circuit it would be found that as the voltage increased so did the current and that, if the temperature of the conductor were kept constant, when the voltage was doubled the number of amperes passing through it would be doubled. This might have been anticipated, for voltage is



analogous to pressure in hydraulics and amperes to quantity and everyone knows that for a given size of pipe the greater the quantity of water passing a given point in a certain interval of time the greater must needs be the pressure behind it.

Plotting this relation by means of a series of points on squared paper, we arrive at a line, a straight one, as shown in Fig. 1. This curve is known as the "characteristic curve for the conductor."

If the same sort of an investigation be made upon an electric arc between carbon electrodes, the same relation of V to I, or of potential to current, does not prevail. It is found that if the voltage be increased the current diminishes, while if the volt-

age be decreased the current increases. If a curve be plotted, it will be found that the characteristic curve of the arc is something like that shown in Fig. 2. A little thought upon this will show at once that a conductor which has a "falling characteristic curve" of this type cannot follow the well-known I=E/R law established by Ohm. It will also be noticed that for points between A and B (see curve), the current and voltage will be very unstable, a slight variation in either producing a comparatively large change in the other. On the other hand, owing to the flatness of the curve between B and C, the relative variation will not be anywhere near as great. A method has been found which utilizes this singular property of the arc in the production of high frequency oscillations, although, as a matter of fact, the effect had been observed and commented upon before a theory for it had been established.

The method in question consists in shunting about the arc a circuit containing inductance and capacity. In Fig. 3, D is a dynamo or other generator of a current of constant potential;

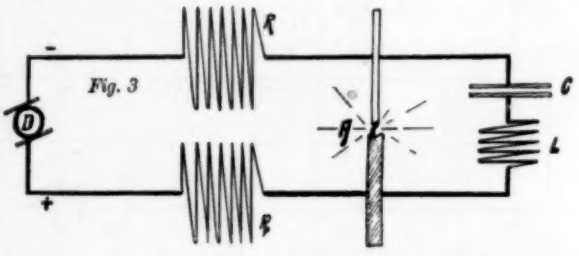


Fig. 3

A, an arc struck between carbon or graphite terminals; C and L, condenser and inductance coil, respectively. Suppose that the shunt circuit be suddenly applied while the arc is burning steadily. Some of the energy will be immediately called from its path through the arc's gases to charge up the condenser, which means, in other words, that while the condenser is being charged up, less current will go through the arc than before. Referring to the curve, Fig. 2, it will be seen that this will cause a rise in the potential difference, or voltage across the arc, which action tends to a still further degree to charge the condenser, until it is fully charged.

Once this point is reached the straying current begins to travel back through the arc, resulting in a sudden drop in the potential difference of the carbons. Referring again to the curve of Fig. 2, it is seen that this tends to make the arc more able to carry

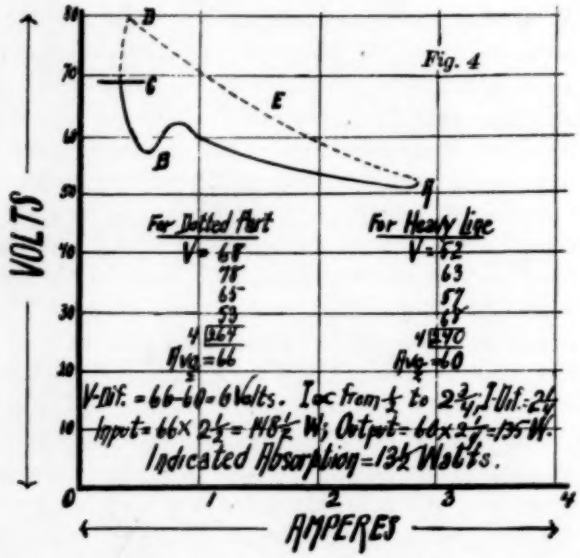
current, hence the condenser begins to discharge itself around through the arc, this action producing a still greater fall in the voltage across the carbons. This discharge is, however, never finished with one such surge for the electric current has inertia and the condenser over-discharges itself, this state of affairs causing a partial re-charging with the same fault again present and a re-discharge, and so on for a number of times which theoretically is extremely large but practically very small. The conditions are aggravated by the presence of the loading coil L.

Referring to the standard formula, $T=2\pi\sqrt{LC}$, it is seen that for ordinary varieties of work the frequency of the discharges can be calculated provided we know the values of L and C. It may be remarked, however, that the use of this formula in this particular case involves taking for granted some things which are very uncertain and probably incorrect to a slight degree. This general theory of the phenomenon, is, however, quite simple and by its use can be explained most of the facts concerned, although it fails entirely to elucidate all of the facts that have been determined experimentally. Thus, while it is not hard to understand that a small current is desired when we want to start the oscillations quickly, it is not so easy to see why the frequency should depend upon the length of the arc as well as on the current, or why there should be a limit to the frequency, which limit is the higher the smaller the current. To explain these facts in addition with those mentioned before, another theory has been proposed, based upon the species of hysteresis exhibited by the arc.

Thus, in the case of the simple circuit proposed, the oscillating current flowing in and out of the shunt circuit is superposed upon the direct current flowing through the arc, forming a pulsating current which is 180 degrees different from, or opposite in phase to the current flowing in the shunt circuit, which means that when the current in the latter is increasing the current in the former is decreasing, so that when the pulsating current passing through the arc is at its maximum, the current in the shunt or condenser circuit is at a minimum. The arc becomes smaller while the shunt circuit current increases and begins to charge up the condenser. However, the negative crater of the arc cools quite slowly and hence the conductivity of the arc remains good and the voltage small. This is graphically shown by the part A, B, C, of the curve in Fig. 4.

The condenser having become fully charged, the current mov-

ing in the shunt circuit grows smaller and that through the arc increases. By this time, however, the negative crater has cooled off slightly, thereby lessening the conductivity of the arc and, hence, it is necessary that a voltage slightly higher be impressed, as shown by the portion of the curve, C D A. The voltage increases until the cathode is again hot, D, and, after this point the voltage falls off rapidly with the increase of current, as seen from inspecting the portion of the curve, D E A. Whenever the capacity is charged it begins to discharge itself through the arc, thus increasing the latter, until the maximum current is reached and the cycle begins all over again. The fact that energy has been absorbed by the shunt circuit is indicated by the fact that the curve incloses an area.



Poulsen found that if the arc be formed in an atmosphere of hydrogen the oscillations are more powerful than otherwise. The easiest way of determining this fact is to cause the arc to take place in the interior of a flame from an ordinary alcohol burner or illuminating gas flame. If allowed to burn in a box full of gas the phenomenon is much more steady compared with the results when the gas is poured upon the arc. The sharpness of tuning is very materially affected in the latter case. The use of a water-cooled anode of copper always contrives to greatly strengthen the oscillations and in order that the length of the arc, and hence the frequency, shall not vary as the burning goes

on, it is found expedient to rotate the carbon electrode slowly in order that a new footing may constantly be found for the arc.

An intense transverse magnetic field is also used and with exceptionally good results. The influence of the field is such that it fixes the arc in a definite place and tends to form a species of blast which removes the ionized air from the vicinity of the electrodes. But, in addition, it increases the voltage necessary to produce a given length of arc, a 3 mm. arc requiring, for instance, 440 volts, and it enables an arc to remain active with larger currents. Good results have been obtained where the arc is formed in steam and especially when it takes place under water and where the steam is produced by the heat of the arc itself, while the results obtained in highly compressed gases by R. A. Fessenden and others have been extremely good.

In order to make use of this device in producing electrical oscillations it is necessary to take account of several practical matters. First, it is necessary that choke coils be placed in the main leads, so as to prevent the oscillations from spreading out into the transmission network. These choke coils may be separate coils or the magnet coils about the arc may be made to serve a double purpose—as choke coils and as exciters for the magnetic cores. The ends of the choke coils nearest the arc will be found to heat up somewhat, indicating how well they serve their purpose.

For another matter the capacity in the shunt circuit must not be too large, else so much current will be drawn from the arc as to extinguish it. In general, if C be reckoned in microfarads and L in microhenries, the ratio L/C must be very large, something like 50,000 or 100,000. Again, if the arc be caused to form in a radial or conical magnetic field, the arc will rotate about the edge of the carbon, thus obviating the necessity for rotating that electrode. Professor Fleming describes a very simple form which can be built at comparatively little expense.

On a cast iron base plate is placed a cylinder of iron about 15 cms. in diamater, about 15 cms. high and 2 cms. in thickness. Inside this iron cyclinder is a vertical iron pin, inclosed in a brass tube, so that cold water can pass up through a hole bored in the pin and down again in the space between the tube and the pin. The top of the brass tube is closed by a recessed copper cap, which is kept cool by the circulating water.

The tube is surrounded by a magnetizing coil and when current passes through this coil it magnetizes the pin and creates a flux which passes up through the pin, then spreads out radially, and completes its circuit through an iron disc with a hole in it placed

on top of the iron cylinder. Through this hole passes a hollow carbon rod and the current forming the arc passes up the brass tube to the cap, leaping across at some point to the carbon, and thus forms an arc between the carbon and the inner edge of the copper cap, which is constructed with a replaceable ring of copper for renewals.

This arc is formed in a strong radial magnetic field, and, therefore, tends to rotate about the carbon rapidly. Some suitable liquid, such as turpentine, petrol, pentane or amyl alcohol is allowed to trickle down the hollow carbon and drop into the hollow cap and be volatized, and thus surrounds the arc with the necessary non-oxygenic atmosphere. It might also be mentioned that in order to protect the iron cover disc from the heat of the arc, the carbon rod should run through some sort of an insulating sleeve, which is fireproof as well. To get the best results, it is necessary to spend much time on adjustment, in determining the best strength of the magnetic field, the supply of hydro-carbon gas and the proper length of the arc. All of these must be determined experimentally by a species of cut-and-try method.

With such a piece of apparatus, properly connected with a source of direct current of 200 or more volts, it will not be very difficult to arrange a wireless telephone which will work over a distance of a mile or more. Capacities of 0.003 to 0.0025 microfarad are common in this work. The very high frequencies used are no great objection, although it is true that such short waves are more greatly absorbed than the long ones, for, since the radiation varies as the fourth power of the frequency and the range increases with the square root of the radiation intensity, it will be seen that if the frequency be doubled, the range of communication should be quadrupled. This objection may be remedied by placing several arcs in series, which being tantamount to increasing the arc length, results in a lowering of the frequency.

For really practical work in telephoning without wires the use of the high voltage arc in highly compressed air is the only satisfactory method, for various reasons, including the probability that a wave nearly sinusoidal is obtained by the latter plan, the disagreeable hissing is avoided and more energy can be derived from the oscillations. In conclusion, however, it may be said that the ordinary arc or the easily constructed special type herein described forms a cheap and convenient source of high-frequency oscillations, and no laboratory worker who is possessed of ordinary facilities should experience any trouble in constructing one.

GENERAL SCIENCE.

By John F. Woodhull,
Columbia University.

The National Educational Association has appointed a Committee on General Science. All persons interested are invited to co-operate with this Committee in finding out what is good material to present and what are good methods to use.

It has been suggested that we gather lists of questions which young persons ask of parents and teachers in search for information in the field of science such as: What is the sun? How does it keep hot? Why does it sometimes turn red? What gives the clouds so many different colors? What makes the street car run? How can animals breathe when under water? Why do leaves of plants turn red in autumn, etc.?

A lawyer testifies that in his profession he has found of great value the general science course which he took a generation ago consisting of the Geological Story Briefly Told and the stories of half a dozen other sciences briefly told. Many intelligent men have testified that what they need particularly is general information in the field of science. It has been suggested that teachers, parents and grown up persons in general send to the Committee lists of facts in science which they by years of experience have found worth while to know.

It has been suggested that lists be prepared of the incredible things persons say and do which show the need for instruction in general science and show what instruction is most needed.

Suggestions for organizing common sense, developing gumption, etc., are in order. Lists of problems are suggested in the field of natural science which require diagnosis at the hands of the ordinary person. In this age of machinery life is becoming increasingly embarrassing to those who regard all mechanisms as uncanny. That education which its devotees are pleased to call the humanities but which seem to leave its disciples incapable of serving humanity is becoming daily more inadequate.

Lists of aims for this work are desired as also lists of sources of information. Lists of fundamental principles have been suggested. It has been suggested that no syllabus be prepared of work expected of all schools alike but rather let it be urged that each teacher should adapt his work to local conditions. It has been suggested that any good work must be considered good preparation for the following years of high school and college.

Facts which will be needed in the future years of any course at school are best taught when they are needed and when they are to be organized for some purpose. It is suggested that sample lessons be published in detail to guide inexperienced teachers in the best method of presenting topics in general science. Several courses in general science have been already published indicating the progress in this matter up to the present time.

All who are interested in this matter are invited to make further suggestions, to criticise those already made, and especially to make some constructive contributions which will in each case be credited to their authors in the published reports of the Committee.

Communications should be addressed to the chairman of the committee, Mr. John F. Woodhull, Teachers College, Columbia University, New York City.

AUTOMOBILES AND THE HIGH SCHOOL.

The automobile industry needs skilled workers, and boys who are interested in being skilled automobile workers need the high school. That's the basis of the school and shop plan now in effect in Lansing, Mich., as reported to the United States Bureau of Education. In Lansing, the high school and the automobile industries of the city coöperate in educating boys who wish to go beyond the eighth grade in school but need something different from the usual academic curriculum.

Boys in the industrial-coöperative course spend the first year wholly in school. After that they divide their time equally between school and shop, working one week at school and the next week in the automobile or gas-engine shop, or wherever they are employed. Thus the present beginning class of twenty, when they finish the preliminary year this June, will go to work as apprentices in Lansing manufacturing plants. They will have two weeks vacation during the summer, and in the fall they will begin the weekly alternating plan. They are paid for their work, of course.

The object of the plan, according to Superintendent Cummings, who inaugurated it after observing the work at Fitchburg, Mass., is not only to provide a rational course of study for pupils who desire specific preparation for a trade, but also "to serve a purpose in the preformance of the school's duty to the industries and to society."

The instructor in charge of the industrial-coöperative course is an admirable example of the new kind of schoolman required for vocational education. He is well educated, but at the same time he is a man of practical training and experience. Not only did he serve at his trade for several years, but he has had experience in teaching as well. It is not often that the schools can avail themselves of vocational instructors of this double qualification, and in this respect Lansing is considered particularly fortunate.

The work is already proving its importance, in the opinion of Superintendent Cummings. He points to the significant case of two boys, who, after having made abject failures of the regular high-school work the year before, are successful leaders in the work of the industrial department.

THE JOINT COMMITTEE ON PHYSICS.

By J. A. Randall.
Pratt Institute, Brooklyn.

There are two questions which have been raised about the work of the Joint Committee on Physics which should properly have a public answer.

The first question is asked by those who understand very well that the Committee was appointed to hasten the evolution of physics into a course preparing for life rather than for college. The questioners want to get some idea as to where the work of the Committee is leading the teachers who co-operate in its work.

The Committee members all agree that whatever we undertake shall not in any way restrict the freedom of choice of physics teachers. Instead, we hope to offer a larger body of material from which to choose and to eventually state some of the principles which should guide such choice.

There have been partisans urging all sorts of innovations and there need be no doubt that the Chairman is guilty of this charge. We very much need, therefore, to establish a broad standard by which to gauge the value of all suggestions. We must first ask ourselves what are the chief responsibilities to the student of all educational institutions. Personally I list these as follows:

I: Physical welfare of the student.

II: The economic welfare of the student.

III: The cultural welfare of the student, under which heading we may properly group a training in all that is implied by the following topics:

a—Ethics.
b—Asthetics.
c—Humanics.
d—Religion, etc.

The value of such a classification lies in the fact that a consideration of it tends to prevent over-emphasis of any one item. Such an over-emphasis upon a single topic results in a movement, now for more Physical Culture, and then for Manual Training or Vocational Education, and so on indefinitely through all the long list. This classification should guide us in our attitude toward those who would have our school work lead by the development of the child's needs and wishes. Without arguing the point, the writer wishes here to indicate that he assumes the teachers' function to be to lead the students' attention and interests to those labors which are appropriate to his stage of develop-

ment and which are most worth while for the student's future as a citizen, and social unit.

In the course of events we must constantly strike a more even balance between all of these apparently conflicting responsibilities. As our life becomes more artificial and divorced from the out-of-door character of activities we must not expect to wait for biological evolution to adapt the race to its environment. Neither should we wait for a natural process of evolution to readjust our people to the suddenly changing condition of our economic life.

In ten years, according to our last census, our electrical industries have suddenly sprung from an insignificant position among our manufacturers to that of 18th in point of number of wage earners. The automobile industry is 19th. Both have far outstripped the general chemical industry, the importance of which is conceded.

In our Northern and Eastern states, like Illinois and New York, we have similar conditions to those in Massachusetts. According to the last census, the statistics for this state show that one person in every average family of six is a wage earner in the manufacturing industries. The agricultural interests in this group of states are relatively small. In New Mexico, on the other hand, less than one person in a thousand is engaged in manufacturing. This state may be grouped with a second large list of states in which over 85% of the population is agricultural.

There has been an interesting series of attempts to introduce material relating physics to its newer applications by an indirect form of legislation. Some have hoped that teachers could be impelled to change their courses, by introducing questions of a practical nature in the state and college entrance examinations. Two sample questions will serve as illustrations. There was a storm of protest raised recently in New York State over the introduction in a Regents Examination of a question calling for a discussion of the electrical ignition system on a gasoline engine. While the question may not have been fair to the teachers of New York State, there are good reasons for teaching the student the theory of everything that pertains to a gasoline engine. There are nearly 2,000,000 explosion engines with electrical ignition in this country. This statement means that one person in every fifty needs to know the electrical ignition system of some engine thoroughly. The writer believes that the majority of male graduates of our high schools need to know enough about automobile engine ignition to be able to understand any special system from

the manufacturers' diagrams of connections and books of information. It is of interest to note in this connection that the automobile industry outranks in value of product and number of people employed the general chemical industry in a ratio of over two to one.

The second question is on the Harvard Entrance Examination published on page 725 of the November, 1912, number of SCHOOL SCIENCE AND MATHEMATICS. It involves computations of cost of operation of a "Hylo" lamp and requires a knowledge of Ohms Law and the electrical units as well as power to apply the information. Here again was an attempt to introduce by legislation a practical problem.

For many teachers the situation is being confused by the multiplicity of the suggestions already made for new material. There is still pressure to urge the teacher to continue to try to cover all of the material that was formerly included in a Physics course. And there are more complications to follow for there are additional considerations which have not yet been seriously considered; for example:

Rural schools and urban schools teach physics with the same type of equipment and with emphasis placed in exactly the same way. Now in certain cities where statistics show that over half of the wage earning students will go to work in some department of a manufacturing industry, the vocational interest demands that the material of instruction should relate less to agriculture and farm industries than in the schools of a state where the population is 85% rural.

In our special industries, the technical worker and the engineer have a notion very different from that of the teacher of what is the most practical information related to his industry. The day has come when it is wise to listen to the criticisms of citizens who know industrial conditions though they may not speak the "research dialect" nor have the other markings of a university education.

The writer has an evening class of fifty mature electrical workers. The Fire Underwriters' Code[1] is on the tongue's end of every wireman and construction employee in the class. They believe that every householder and factory man should know it as a protection against electrical contractors. They believe that every high school graduate should understand enough about *elec-*

[1]Copies may be had by applying to the Mutual Factory Underwriter's Association, 31 Milk Street, Boston, Mass., or the National Board of Underwriters, 137 Williams St., New York City.

trical construction to be able to get a set of rules and decide for himself whether construction work has been so installed as to make his insurance valid. Electrical engineers insist that while there may be inspectors who are responsible for the installation, inspectors can never take away entirely the personal interest and moral responsibility of the tenant and owner.

The writer agrees to the extent of saying that the physics teacher needs to have a clear appreciation of the commercial importance of such matters as electric ignition systems and the "Electric Rules."

There is surely enough truth in the point of view of business and technical men to warrant us in giving their suggestions due consideration. It is the intention of every fair-minded educator to give due weight to suggestions coming from any source.

Statistics such as those offered by Dr. Woodhull in the April issue of SCHOOL SCIENCE AND MATHEMATICS indicate clearly that if we are to adjust our courses in a way to confer the greatest benefit upon the greatest number, we must plan our courses chiefly for those who are soon to leave school, rather than for those who may be expected to remain the full period of years and complete the work of any school.

A general science course is needed in the first year of the High School curriculum. This course should teach, primarily, all of the science pertaining to industrial life which it is possible for a student at that stage of development to assimilate. A growth in general information and in appreciation of pure sciences should also be aimed for. Such a course must contain a large amount of physics if the industrial value of the content and the interests of that majority who will leave school before the third year of the high school are to be seriously considered.

My answer to the first question is, therefore, that we are facing a readjustment of our physics course to enable us to change the contents and methods to harmonize with commercial and home conditions on the one side, and better educational methods on the other. In the judgment of the writer, this means that in each school there should be given a course adapted to the future needs of the students and consisting of a few topics and facts well-taught.

It is probable that this cannot be done without abandoning the attempt to organize a course about a systematic philosophical outline of the complete physical science. We may have to abandon the plan of analyzing the subject into Mechanics, Heat, Sound, Light and Electricity. Continuity of presentation may be

obtained by relating the content selected about such topics as Energy, Uses of Materials, etc.

The transition of a new type of physics course must be slow. Yet in many important ways it has begun. In the text book by Mann & Twiss, we may see the first definite successful break from the old systematized outline. There are other less conspicuous instances of such breaks in current books and I believe they mark the beginning of a break all along the line. In such books as that of Black and Davis in which the formal outline is adhered to, there is a thorough-going attempt made to introduce applications first and then theory to explain the practical problem presented by the application.

There are hundreds of teachers who are now modifying their course. The New York Department of Education has announced a ruling favorable to the introduction of new courses. In the files of the Committee there is ample evidence to prove that teachers have passed the stage of talking about a change and are actually making one.

The second question that is asked, is, what is the Joint Committee doing?

The Joint Committee was organized to facilitate the transition from formal physics to a vitalized physics.

The Committee believes that for the present no outline of a course should be attempted. Any new course must be largely dependant upon the development of new laboratory exercises. The Committee is accordingly devoting its energies chiefly to circulating designs of new laboratory equipment and new laboratory exercises. These exercises have all been found a success by some one teacher. They are given out in the hope that they will be found valuable to other teachers and an aid in evolving the courses given from a purely college preparatory type into a course in which a fair balance is struck between the cultural and the vocational motives.

The Chairman has felt that the teachers should have a greater first-hand knowledge of the industries if material from the industrial worlds is to be introduced into their teaching. Since the teachers cannot all visit manufacturing plants the Chairman has induced certain manufacturers to send to teachers reliable information concerning their manufacturing methods.

Before this issue of SCHOOL SCIENCE AND MATHEMATICS reaches the reader he will already have received through the mail a sample of the publications to follow. The Weston Electrical

Instrument Company has issued four monographs at the request of the Chairman and a fifth will be issued if there is a demand for further material on the subject.

The following designs and laboratory exercises are a few of those which may be had by addressing the

JOINT COMMITTEE ON PHYSICS,
Office of the Chairman,
Pratt Institute,
Brooklyn, N. Y.

(References are to page numbers of Vol. XII of SCHOOL SCIENCE AND MATHEMATICS.)

1445-5 Prony Brake—Worcester Polytechnic Institute Design.
1445-6 Prony Brake—P. M. Dysart, Pittsburg, Pa.
12-8C The Hammer—H. L. F. Morse, Troy, N. Y.
1872C Gravity Apparatus. C. M. Wescott, Hollywood, Calif.
1413-R Simple Crane, with Compression Balance. F. A. Reidy, San Jose, Calif.
1407-G Gas Furnace. (See article by Mr. Beltz which will be published in the October issue of this Journal.)
1407-E Electric Furnace. (See article by Mr. Beltz which will be published in the October issue of this Journal.)
845 Truss Units. Prof. Harvey N. Davis, Harvard University.
843 Electric Colorimeter. Prof. J. A. G. Shirh, Kansas State Normal School, Pittsburg, Kan.
844 Hydraulic Ram. Dr. W. A. Hedricks, Washington, D. C.
1413 Simple Truss. Page 201, Fig. 1.
141 Hoisting Crane. Page 204, Fig. 4.
142 Suspended Body Apparatus.
1428 Center of Gravity.
1411 Adjustable Incline Plane.
1410 Screw Jack.
1446 Reynold's Chain Drive. Page 506, Fig. 11. Right background.
1461-1 High Machine Table. L iron 2x2x$\frac{1}{4}$, top 15x29, height 54". Right background.
1452-A1 Testing Table. L iron 2x2x$\frac{1}{4}$, top 49$\frac{1}{2}$x28$\frac{7}{8}$, height 27$\frac{1}{2}$". Page 506, Fig. 11. Left foreground.
1452-B1 Testing Table. (As above except top 49x32$\frac{7}{8}$".)
1442 Wooden Laboratory Table. Top 58x30"; height 30".
141 Wall Crane. 500 lbs. capacity. Page 508, Fig. 14.
14-5 Guyed Crane. Height 102". Page 513, Fig. 20.
146-1 Index of Refraction. (For direct transfer of angles.)
22-2C Gas Pressure of the Laboratory. (Open arm manometer.)
22-3C Water Pressure of the Laboratory. (Closed arm manometer.)
14-2C Shear Legs. Page 510, Fig. 16.
13-2C Roof Truss. Page 202, Fig. 2.
14-4 Arch. Page 507, Fig. 12.
1440-2 Flexible Coupling. (For both high and low speeds. Designed also as a spring holder for the transmission dynamometer.)
C-447-1 Transmission Dynamometer.
1453-2 Terminal Stud. (Switchboard type.) Page 330, Fig. 8.
1453-2B Terminal. (Flush type.) Page 330, Fig. 7.
1431-1P Starting Box Panel.

1454-1 Wall Panel. (Two pole switch.)
1454-2 Wall Panel. (Three pole switch.)
1431-1S Motor Table Slate.
148 Model Fields. (Two pole.) Refer to article by Mr. F. A. Clark, Jr., which will be published in the October issue of this Journal.
148-2 Model Fields. (Four pole.) Refer to article by Mr. F. A. Clark, Jr., which will be published in the October issue of this Journal.
148-3 Model Fields. (Four pole, sheet iron.)
1430 Carbon Rheostat. Page 330, Fig. 6.
1434 Parallel Lamp Boards. (Will pass "Underwriters' Inspection.")
1453-2B Model Lighting Circuit. Page 334, Fig. 10.
43-2 Coils for Series-Multiple Connection. Page 330.
43-6 Series Lamp Board. Page 330, Fig. 6.
Floor Plan of Pratt Institute Physical Laboratories.
880 Model Dynamo Adapted for Over 20 Lecture Experiments. By C. F. Adams, Detroit, Mich. Vol. XIII. Page 232.
Model Dynamo. (Half H. P. frame.)
890 Induction Effect Apparatus. C. S. Cooke, Detroit, Mich.
215 Conveniences in Connection with the Photometer. Mr. W. R. Pyle, New York City.
218 Conveniences in Connection with the Production of Real Images. Mr. W. R. Pyle, New York City.
841 Water Motor. (Cheap construction.) F. A. Clark, Sr., Meriden, Conn.

EXERCISES:

855 Cost of Operating Electric Flat Iron. C. W. Wescott, Hollywood, Calif.
850 Efficiency of an Electric Stove. E. R. Smith, Syracuse, N. Y.
Practical Suggestions. H. C. Krenerick, Milwaukee, Wis.
Practical Suggestions. A. L. Jordan, San Francisco, Calif

Further contributions are solicited by the Committee.

1453-6 Socket and Jack. Dr. W. A. Hedrick, Washington, D. C.
879 Apparatus for the Demonstration of the Induction Motor. By A. Haven, South Riverside, Cal.
897 Directions for Building a Plate Rectifier. By C. M. Westcott, Hollywood, Cal.

TEACHERS NEEDED IN CHICAGO.

There is at present a great demand for high school teachers in Chicago. This is especially so in the sciences, mathematics and manual training. The rapid growth of the city and the opening of two great new high schools is the cause of this need. Here is a splendid opportunity for teachers, in the subjects named, to get into this big system.

In science the most urgent need is in departments of physics and chemistry. There are now no eligible names on the list, all candidates having received appointments. It probably is not generally known that the maximum salary has recently been raised to $2,600.00. Teachers of considerable experience are now assigned at a very much higher initial salary than formerly.

Examination will undoubtedly be held during the latter part of June. Persons contemplating taking the examinations should write at once for information to the Department of Examinations, 828 Tribune Building, Chicago, Ill.

EVOLUTION OF THE HIGH SCHOOL COURSE IN AGRICULTURE.

By Josiah Main,
Hays, Kansas.

Great diversity of opinion prevails concerning the method of formulating high school courses in agriculture. Nature study enthusiasts, reassured by the success of their subject in the elementary grades, would project it into the high school and call it agriculture, regardless of the fact that nature-study lacks the essential economic factor necessary to the budding vocational interests of the adolescent, and the further fact that it consists of isolated data, while we are told that all high school subjects should be organized into sciences.[1]

The great success of the agricultural colleges constitutes a strong argument in favor of handing down their courses into the high school. Here again educational landmarks are in danger of being ignored in that the admitted aim of such courses is narrowly economic and would force that aim upon a school whose duty it is to foster and retain general interests. However much their ideals might suit the strictly agricultural high school, no special vocation as a dominant interest can or should be permitted to drive out all other subjects that do not correlate with and contribute to its purposes. The test of the agricultural college is primarily economic. The test of the high school is sociological, which includes somewhat more than economic success.

The muscular concomitant of the learning process—the unifying and vivifying "kinaesthetic factor"—essential to early edu-

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[1] To describe without rising to the causes or descending to the consequences is no more science than merely and simply to relate a fact of which one has been a witness.—*Guyot.*

Whenever the study of nature enters upon organization of the whole and the pigeonholing of facts in some general scheme it becomes science, and in our usage of the term ceases to be nature-study.—*Coulter and Patterson:* Practical Nature Study, p. 17.

Nature-study represents one of the greatest problems of education, and it will not be solved by schemes imposed upon teachers, but by the teachers themselves attempting to work out in a practical way certain evident principles.—*Coulter and Patterson:* Practical Nature Study, p. 18.

It is * * * the business of secondary education to raise all subjects which it touches to the plane of science, by bringing all into the point of view of organizing principles.—*E. E. Brown:* The Making of Our Middle Schools, p. 4.

cation, continues with but gradual abatement and modification into adolescence. It is largely this which gives general educational value, in addition to their economic value, to the manual subjects of the high school curriculum. The relation of the agricultural work to the correlated science work of the student in early adolescence is therefore largely the relation of the "intellectual-motor" end of the process to the "sensory-intellectual" and they are mutually necessary.[2]

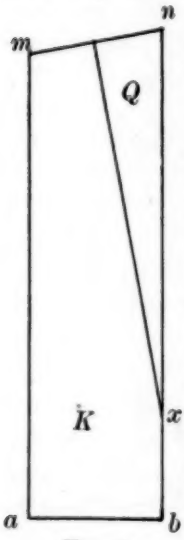

FIG. 1.

But if agriculture in the public high school is not to be grown up nature-study nor an invading pedagogical misfit from the opposite direction, there is an independent method of approaching and developing this subject from the lateral point of view of adolescent psychology that alone can give it a permanent success. This method of approach admits of graphic presentation.

If, in the quadrilateral, *abmn* (Fig. 1), there be regularly arranged all of the subjects of the high school science course, beginning at the top with first year science and ending at the bottom with fourth year science, those at the top should have more of the "applied" and less of the "pure" science phase, the necessity for vocational applications, represented by the area Q, diminishing toward the last of the course.

If, in the quadrilateral, *cdmn* (Fig. 2), there be arranged the agricultural work appropriate to a high school course aiming at the preparation of an operative, an interpretive knowledge of a certain amount of science, represented by the area D, would be requisite to his agricultural work. For such purpose this amount of correlated science would diminish throughout the four-year course, thus ending with practical work and agricultural lore that call for no scientific knowledge beyond that acquired in previous years.

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[2] Each normal human being is fitted with a dual system of nerves, the afferent and the efferent. This fact has not always been duly recognized in educational theory, nor its wide-reaching importance fully appreciated; for in fact, all important educational practices should depend upon sensory and motor reactions and their interelations. * * * It is likewise a well-known fact that individuals differ not only in the amount of their original endowment, but also in its distribution, some being stronger in the sensory-intellectual, some on the intellectual-motor side.—*DeGarmo:* Principles of Secondary Education, Vol. I., pp. 20-21.

Two students entering the freshman class of the high school, one taking the agricultural course and the other the science course, would thus have very similar work at the beginning—each having a large share of correlated science work and agriculture.[3] And since no emasculated science or purposeless muscular exercise will satisfy either of these needs, it is in the interest of economy that the two types of students be combined in the same class. But each having a different goal in view, their courses will gradually diverge until the common elements, both scientific and agricultural, disappear.

FIG. 2.

The relation between these two courses may be represented graphically by combining the two preceding figures in the figure *abcdmn* (Fig. 3), the area Q representing an essential part of the agricultural course that is at the same time necessary to a correct demonstration of the science work, D representing a portion of the regular science work necessary to the agricultural student, their combined area—the extent to which the two courses coincide—representing an economy of pedagogical effort and an assurance of the best presentation of both the agricultural and the science work.[4] K and M represent uncorrelated science and agriculture respectively. Both the science work, KD, and the agricultural work,

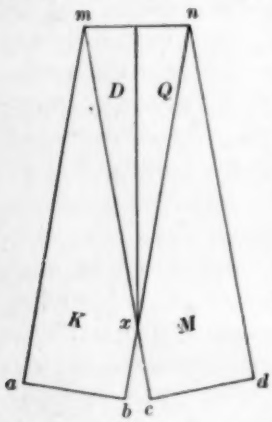

FIG. 3.

[3] Secondary education is differentiated education in its earlier processes. It makes the preliminary survey of the student's special aptitudes and capacities, with a view to discovering, to himself and to those most interested in his future, what there is in him that may be made of most worth to society, and so most serviceable to his own self-realization.—*Brown:* The Making of Our Middle Schools, p. 5.

[4] Certain phases of agriculture, as they can be taught, especially in a good high school, are a valuable means of education for any man, whatever his later occupation may be. But if the school is situated in a farming community, it should add many other courses for professional reasons, which would be valuable chiefly, if not exclusively, for those who are looking forward to farming as a business.—*Davenport:* Recent Aspects of the Nature Study Movement.

MQ, are thus seen to consist of two portions, one of double and the other of single purpose.

Thus, for example, such a subject as "plants" written across the middle of the diagram would be cut into four portions, signifying (1) its treatment as a matter of pure science, (2) the portion of botanical knowledge necessary to an agriculturist as well as a scientist, (3) agricultural exercises to which botanical knowledge is essential and which furnish the best means of imparting such knowledge to the student of science, and, (4) that portion of the subject consisting of work with plants necessary to the agriculturist but outside the needs of the science student.

At this place it is well to call attention to the fact which may be inferred by projecting the lines of (Fig. 3) backward toward the elementary grades, namely, that below the high school no effort should ordinarily be made to distinguish between or try to isolate the science work, on the one hand, and its vocational, hygienic, or domestic applications on the other.[5]

But it should not be inferred from the bifurcation of the science and agricultural courses which comes as indicated by the letter x, in the latter part of the high school course, that thereafter the science work is to be wholly mental and the agricultural work wholly muscular. For the later science work through its accompanying laboratory exercises gradually takes on a variety of refined adjustments more suited to later adolescence, while the agricultural course has its practical vocational lore, each serving to properly balance the educational pabulum of the course to which it pertains.[6]

And incidentally, attention may be called to the mistake formerly made in limiting the study of botany to the area K, or at most, KD, and the similar mistake which would result from limiting the economic course in plant husbandry to the area MQ

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[5] The most generally valuable elements of the environment having been introduced into the elementary curriculum, there is not as much need for a large body of prescribed elements in the secondary curriculum. The basic representativeness of the elementary course, more than the age and nature of the adolescent pupils, allows election in the high school.—*Heck:* Mental Discipline and Educational Values, p. 138.

[6] A large part of the best and most advanced scientific work involves a great deal of manual skill, the training of the hand and eye. It is impossible for one to be a first-class worker in science without this training in manipulation, and in handling apparatus and materials.—*Dewey:* The School and Society, p. 120.

as an uncorrelated course may do. The evident unity of this combined subject is too fundamental to be ignored, though the location of the point of bifurcation, x, which marks the final separation of the two courses may still be a matter of debate.

The restricted application of "disciplinary" exercises in education, and the necessity of common elements as "channels of transfer" between the subject pursued as a school exercise and the situation to which the student is expected to apply his training, is now generally acknowledged. Such common elements between the agricultural work and the science work are provided by the foregoing method. In the diagram (Fig. 3), the common area DQ represents an *identity of substance* which it is good economy to recognize by a combination of classes in science and agriculture. And judging by the success of the teaching of "Pure" science by methods of applied science, the area has an even greater significance as representing an *identity of procedure* which such combination of classes compels.[7] But the goals "science" and "agriculture" being divergent preclude an *identity of aim* after the student has proceeded so far to have an aim.[8]

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[7] Pure science is not for its own sake, but becomes pure precisely as it becomes useful in bringing a race to even more complete maturity.—*Hall:* Adolescence, Vol. II, p. 56.

What people call applied science is nothing but the application of pure science to particular classes of problems. It consists of deductions from those whose general principles, established by reason and observation, constitute pure science. No man can safely make these deductions until he has a firm grasp of the principles; and he can obtain that grasp only by personal experience of the operations of observations and of reasoning on which they are founded.—*"Huxley":* Science and Education, Chap. IV.

[8] Vocational training is to be postponed as long as possible. It is to rest upon the most extended general schooling which the individual can get.—*E. E. Brown:* The Making of Our Middle Schools, p. 459.

The human plant circumnutates in a wider and wider circle, and the endeavor should be to prevent it from prematurely finding a support, to prolong the period of variation to which this stage of life is sacred, and to prevent natural selection from confirming too soon the slight advantage which any quality may temporarily have in this struggle for existence among many faculties and tendencies within us. The educational ideal is now to develop capacities in as many directions as possible, to indulge caprice and velleity a little, to delay consistency for a time, and let the diverse prepotencies struggle with each other.—*Hall:* Adolescence, Vol. II, pp. 88, 89.

The high school, therefore, is the place where the boy shall find himself to the end that if he goes to college he will upon matriculation have clear ideas about what he intends to do, and if he does not he can go out from the high school at once and take some useful place in the world's work.—*Davenport:* Education for Efficiency, p. 71.

The idealization of each course comes in the final uncorrelated portions, K and M, and at a period in adolescence when ideals are most powerful.[9]

In writing the various science subjects into the area, *abmn*, the order is dictated to a great extent by the character of the appropriate manual operations that accompany each and determine their best sequence. This having been done, the correlated agricultural work may be indicated by placement in the area *cdmn* so that their horizontal opposition results when the two areas are again combined into the figure *abcdmn* (Fig. 4). The accuracy with which the placement of agricultural subjects both correlates with the sciences and agrees with the motor requirements of the various subjects, coarser adjustments and close correlation coming early in the course, and finer adjustments and less correlation occurring in the latter part, is more than a mere coincidence, as owing to the unity of this combined subject it was all determined by the correct placement of the science subjects.

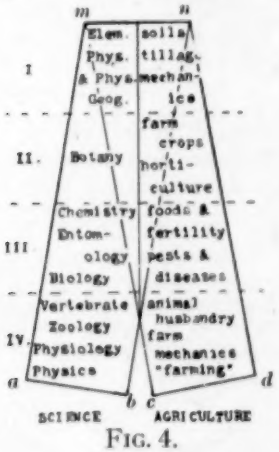

FIG. 4.

In the combined group of science and agriculture, the former includes matter whose formulation inclines more toward psychological authority, while the latter tends to be informal and sociological and less affected by selfish motives in its promulgation. In fact, agricultural exercises, vary all the way from a purely formal to an entirely informal

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But what is more serious is the generally recognized fact that pupils who excel in school are often beaten in professional or business life by fellow-pupils who ranked below them in class standing. The school abilities acquired through school activities are not in these cases carried over into the environmental activities outside the school. This is due to the difference between the matter and the method of the two activities and to the consequent inability of the pupils to make success in the one issue into success in the other. If there were such a transfer of acquired ability as the doctrine of formal discipline implies, there would not be such a difference in the ranking of individuals in the two activities.—*Heck:* Mental Discipline and Educational Values, p. 44.

[9] The doctrine of formal discipline assumed that the mastery of a certain subject gave one an increased power to master other subjects. It is clear that there is a certain amount of truth in this statement, provided that we understand very clearly that this increased power must always take the form of an ideal that will function as judgment and

character. These latter informal exercises, such as home projects and community services, lying far over on the practical and sociological side and outside the preceding diagram, demand special attention, constituting as they do the vital connection between "the school and society."[10] This collateral, or extra-program realm while it hopelessly bewilders the pedagogical formalist, constitutes the source of vitality for the whole group.[11]

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not of an unconscious predisposition that will function as habit. In other words, unless the ideal has been developed consciously, there can be no certainty that the power will be increased, no matter how intrinsically well the subject may have been mastered.—*Bagley:* The Educative Process, p. 216.

[10] The psychology of the child and his physical well being should receive attention from experts; but the teacher of the future needs specially to study sociology and to come into contact with old and young of all conditions of life. Sympathetic knowledge of the child's ideals is more desirable than further analysis by teachers of the "psychology" of the child.—*Carlton:* Education and Industrial Evolution, p. 312.

The child can carry over what he learns in the home and utilize it in the school; and the things learned in the school he applies at home. These are the two great things in breaking down isolation, in getting connection—to have the child come to school, with all the experience he has got outside the school, and to leave it with something to be used in his every day life.—*Dewey:* The School and Society, p. 97.

The outside environment must be made into the meaningful school environment of the pupil and there is no need why, in this process, the elements of the outside environment should be misrelated or misvalued. On the other hand, it is only in so far as these two enviroments are similar that the child lives in school, a life that has functional value outside.—*Heck:* Mental Discipline and Educational Values, p. 120.

From the standpoint of the child, the great waste in the school comes from his inability to utilize the experiences he gets outside the school in any complete and free way within the school itself; while, on the other hand, he is unable to apply in daily life what he is learning at school. That is the isolation of the school—its isolation from life. When the child gets into the schoolroom he has to put out of his mind a large part of the ideas, interests and activities that predominate in his home and neighborhood.—*Dewey:* The School and Society, p. 89.

This is why many teachers do not know the subject-matter or method they teach; in knowing the elements apart from the environment which gives them value they really do not know what their value is. This is probably the weakest point in our teaching force—the ignorance of teachers regarding the environmental relations and values of school studies. Their training should be more in practical sociology and less in hypothetical pedagogy.—*Heck:* Mental Discipline and Educational Values, p. 117.

[11] Such scientific goods as can be metered, inspected and examined by mass methods, tabulated and schematized, always soon seem shopworn to youth who want somewhere room for individuality, if not for distinction, and resist curricularization of knowledge. The pupil is at the age of spontaneous variation which at no period of his life is so great.—*Hall:* Adolescence, Vol. II., p. 509.

Its relation to the subject may be indicated by the area, *efgh*,

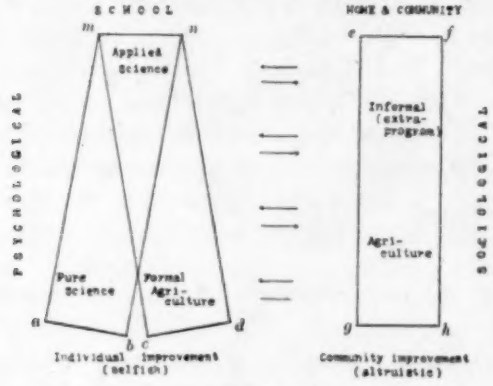

FIG. 5.

(Fig. 5), though giving it such form is at the risk of indicating a definiteness and isolation which it does not possess. It has to do with the care of animals, the culture of crops, excursions of observation, the application of school learned knowledge in the home and the community, and the idealization of local industries and practical services.

The familiar portion, *abcdmn*, with its distinct areas, constitutes the portion of the combined *fundamental sciences* and *formal agriculture* which, with their common bond of *applied science*, may be called the formal side of the subject, and is readily adjusted to school courses and programs. The entire scheme has a polarity such that in passing from left to right it becomes less psychological, formal, and scientific, and more practical, liberal, and sociological. This polarity, which a divided system of schools based on "cultural" and "practical" ideals would break, is essential to a proper teaching of every subject and a proper education of every child.[12] The scholar can never

[12] In order to insure well-rounded development, mental and manual work should fall to the lot of every man and woman, irrespective of all artificial class distinctions. * * * The monastic ideal of education is now obselete; education should be an integral part of life. In order to prepare for future usefulness of students, school work and practical work should be drawn closer together. Coördination of theory and practice, both as to time and place, is desirable. The customary wide separation of the two is the cause of serious waste of human energy * * * The world needs the doer and the thinker united in one individual.—*Carlton:* Education and Industrial Evolution, pp. 91-92.

The line between the technical and the non-technical, between the nar-

overcome his traditional helplessness until the training which perfects his scholarship gives it appropriate application, nor can labor acquire its deserved dignity until it be given its complete enlightenment.[13] It is thus seen that to be properly set into a high school course, the formal agricultural subjects, constituting the definite and informational portion, must correlate with the sciences on the one side and have vital connection with community interests on the other. It is on this informal community side that the chief local differences in high school courses should be made.

And this is the way the course should grow, not up from nature-study nor down from college agriculture, but laterally from the formal side whose pedagogical landmarks are too well established to be ignored. This method correlates it with all other subjects, applies the test of *purpose* to the whole curriculum, and relates the school to the community. But there is danger that this subject will not get outside its formal phases if left to those who are not in sympathy with the idea that training in vocation is essential in the education of every normal adolescent. The teacher of agriculture in the high school should deal direct with his community, taking his position well out on the sociological side, though it be at the risk of being unappreciated by his co-workers, and the science teacher should extend his work in that direction so as to connect with him.

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row and the liberal runs across individuals and not between them. Every properly educated man is trained both vocationally and liberally, but one vocation is not necessarily more liberal than another except as the practitioner makes it so.—*Davenport:* Education for Efficiency, p. 19.

[13] A distinctly learned class is henceforth out of the question. It is an anachronism. Knowledge is no longer an immobile solid; it has been liquefied. It is actively moving in all currents of society itself.—*Dewey:* The School and Society, p. 40. (*Kansas School Magazine.*)

THE RE-INTRODUCTION OF ARITHMETIC INTO THE HIGH SCHOOL COURSE.*

By Harrison E. Webb,

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The mathematical curriculum of a manual training high school is one of the most difficult of the problems which this type of school has to face. The traditional high school course has been tried and found wanting for various reasons, some of which may well be enumerated here.

The first of these reasons is identical with the fundamental question as to whether the orthodox canon of high school mathemathics has ever justified its existence from any point of view. The canonical sequence of algebra, plane and solid geometry, and plane trigonometry seems to have been imposed upon American high schools by the colleges, as the colleges themselves came to need more and more time for the physical sciences and history. Fifty years ago many students entered our colleges from the grammar schools through the intermediary of a year or two of private tuition. This tuition, as well as the grammar school teaching, was largely informative in character in that it led directly to an entrance examination, which was to test whether the amount of information which the student had acquired was sufficient to enable him to proceed further in his studies. The preparatory work in mathematics was scarcely less informative, in this sense of the word, than that in Latin and Greek.

Once inside the sacred portals of the college, however, the student was confronted by quite a different situation. Here his studies had an aim which was distinctly disciplinary. It was safe to assume that one who had "brains" enough to master the amount of Latin, Greek, mathematics and metaphysics required for graduation from a college would succeed as a lawyer, or a doctor, or a clergyman, or in any thing else he might undertake. It was assumed that his life work commenced at "commencement" and not before, and that his college had inspired in him the habit of success.

The immense broadening of the field of human knowledge during the past fifty years, roughly speaking, has brought about a curious interchange of purposes of high school and college.

*Read before the Association of Mathematics Teachers of the Middle States and Maryland, held at Philadelphia, Nov. 24, 1912.

During this period the colleges rapidly enlarged the scope of their instruction. Scientific courses expanded and multiplied enormously. English literature was raised to the dignity of university consideration. History was given a place worthy of its high importance in liberal education. Professional and graduate schools in law, medicine, engineering, and theology appeared in great numbers, and college education in the broad sense of term, became distinctly informative in character along definite lines which should lead directly to professional work.

Meanwhile the secondary school acquired a distinct status as the proper intermediary between the grammar school and the college, and its work gradually took on a disciplinary character. The idea of secondary education as primarily a discipline was encouraged by the colleges as it came to be recognized that a mind properly trained through four years of high school work can later acquire a great deal of information on very short notice.

This change in the aim and purpose of the high school, however, was accompanied by another change in a widely different direction. Secondary schools throughout the country were transferred from private to public supervision and became an integral part of our admirable public school system. An enormous increase in attendance was the result, and as a further result the burden of selecting proper material for the colleges was placed upon the high school authorities. It soon appeared that by far the larger proportion of high school students, for economic or other reasons, were not to enter college at all, nor even, perhaps, to "graduate" from the high school itself.

The problem of reconciling a proper degree of discipline with the imparting of a reasonable amount of information in a high school course is only in process of solution. It would be a very rash performance to predict the outcome. What part is mathematics to play in solving the problem? The remarkable thing about this phase of the question is that amid all the changes in secondary school curricula—the gradual disappearance of Greek, increased emphasis upon English, improved methods of teaching modern languages, and other improvements too numerous to mention, high school mathematics has stood stock still. I suppose that this statement should be qualified by reference to the addition of a certain few topics, and the elimination of two, highest common factor by the Euclidean method, and the so-called theory of limits in geometry. Even this awe-inspiring transformation has taken place only within the last decade.

Why this conservatism? Why has it taken longer, as some one has said, to eliminate the absurdities of the "theory of limits" from geometry than it took for Alexander to conquer the world, or for Luther to reform the religion of half of Germany?

The chief reason, I think, lies in the necessity placed upon teachers of judging pupils as well as instructing them. And judgments such as we must make, among students whose aims range all the way from entrance into the most exacting technical schools to the killing of time until somebody in authority sets his foot down, such judgments seem to demand great precision in the determination of proper standards. The result is that our mathematical curriculum has become standardized to an extent which is almost inhuman. We have set the orthodoxy of our topical analysis above the welfare of the student. We have even set it above the spirit of the mathematics. Our teaching has taken on more and more the character of an inquisition. A teacher of high school mathematics of ten years' experience not only knows every twist and turn of the subjects he teaches, but he can generally foresee just what mistakes are going to be made in his classroom, and what students are going to make them. And he concludes his year's work with examinations, the results of which he can foretell to a nicety, so rigid is our adherence to the classical forms of our abstract material.

And yet it is a fact that the curriculum itself is largely accidental. The logic of the situation is decidedly vague, to say the least. There is no logical reason why our preparatory mathematics "should not now be in the field of substitution groups or of elementary vector analysis, if the Arabs or the Greeks had happened to think of them!"

The alteration of our standards is no easy task, however, even with the encouragement of the very liberal spirit recently shown by the colleges in this regard. Imagine trying to introduce into a high school such mathematical courses as were above mentioned! I would not be so bold at this time as even to recommend any very radical changes. But first of all we must pull down our fetich; we must lose entirely our present high regard for mere intricacy. We must appreciate that neither scholastic ability in general, nor mathematical ability in particular, is to be measured in terms of the negative exponent, or of the geometrical locus. But we can afford to be careful in making improvements. We are not alone in our efforts toward reform. Religious heterodoxy is in the air. Professor Bergson is treating our metaphy-

sicians to a series of moral cold baths. Eminent statesmen are thundering against the intricacies of the law. Standards of morality are concealing themselves behind the "higher good." Let us by all means be careful.

Let us be careful in considering the argument from discipline. Within the last decade we have heard much of the "real problem," and its importance to vocational courses of study. But can we safely assert that we are able to reproduce in our schools such real conditions as the student must meet in his work outside? To just the extent to which we fail to do this our high school studies are essentially disciplinary. It is doubtful if, having assumed the responsibility of judging the absolute merit of our students, we can ever escape from disciplinary methods. The question is whether under existing conditions the discipline is of the right sort. Most of us will agree, I think, that it is not. If it were, we would not have to listen to the indignant protests of the teachers of physics that they are obliged to spend more time in instruction in mathematics than in what they regard as their own proper field. If it were, we would not have presented to us constantly the spectacle of the student who can disentangle the most elaborate complex fractions, and yet who cannot solve the simplest examples in chemistry under the law of contsant proportions. If it were, we would not "pass" students who can solve simultaneous quadratic equations of the fourth degree with the greatest of ease and yet who cannot determine the horse power of a steam engine when the formula and the necessary data are given them in the plainest of terms.

What are we doing? What sort of mathematical fare are we providing for our charges? Take the average first year course, for example. What do we find? Forty-seven varieties of factoring, all by guess work, and all of which we curse deeply, if not aloud, when we come to quadratic equations; algebraic fractions which reach across the page of the textbook; simultaneous equations in innumerable variables, which appear again only as a proper field for the application of determinants, which we do *not* teach, or in geometry of three or more dimensions, of which not more than one out of five hundred of our students ever hears; utterly impossible exponential relations; and finally problems! Inconceivable dogs chasing incomprehensible rabbits; railroad trains, the data regarding which no one but a lunatic would ever present to a train dispatcher; the time when the hands of a clock are at right angles—this problem has a factitious interest

for our students in that it affords them an excuse for glancing at the clock face, which they are generally anxious enough to do. And so on, *ad nauseam*.

In the meanwhile, what are we failing to teach? Any notion whatever of the significance of approximate values of irrational or imperfectly determined numbers; the faintest glimmer of the function concept, which is perhaps the most important of all fundamental concepts of elementary mathematics; ratio and proportion in any adequate sense of their relation to physical law; and anything like a sure knowledge of the four fundamental operations and the laws governing them.

And then when we reach the second year, we drop the whole body of algebraic knowledge which we have been so careful to inculcate and plunge our classes into a sea of Euclidean metaphysics as if algebra had never existed. Small wonder that the teachers of scientific branches have trouble with the students we send to them! Small wonder that so many of the students themselves look upon the mathematics as a stale and unprofitable thing! Small wonder that the colleges complain without ceasing of the hopelessly inadequate mathematical training of those we send to them!

And yet, absurd as the present situation is, we are wise in moving slowly toward its betterment. The mathematical curriculum, like the tariff, should be revised only by slow degrees. Most of us are painfully aware of the demoralization which has resulted from certain well-meant attempts at radical reform. There was the real-problem movement, for instance. Nothing should be in closer theoretical accord with the best pedagogics. And yet those of us who tried conscientiously to limit the scope of algebraic application to actual conditions arising out of the shops and laboratories were completely at a loss owing to the paucity of meterial. Many hours we spent in the search for quadratic equations only to be rewarded with $S = u_0 t + \frac{1}{2} g t^2$ standing in solitary grandeur.

What I have to propose is not so much a new curriculum as a renewed emphasis. The word which best conveys the meaning of what I would like to see emphasized is "application." This word has to my mind many connotations; first it involves the organic unity of our teaching, in that the importance of a principle or of an exercise lies in its bearing upon what is to follow, the more direct the more important. The future outlook of a science is its chief source of interest. We have, I believe, partly

through the Greek tradition and partly through an erroneous psychology, laid altogether too much emphasis upon the derivative side of our science. If a student, for example, is forbidden to use his algebra freely in geometry, where can he expect to use it?

Second, the word "application" seems to me to involve all that is vital in the doctrine of correlation as applied to high school studies. Experiments along this line have led many of us to the conclusion that the proper place for correlation is in the mind of the student, rather than in the topical analysis of the curriculum. Why not take this point of view frankly? To cite an instance or two; it is one thing to insist that geometrical figures shall be drawn with all the care demanded in the drafting room; it is quite another thing to emphasize the geometrical principles underlying the use of the T-square, or the parallel ruler, or the construction of a spiral. It is one thing to teach the atomic theory of heat to a first year class in high school. It is quite another thing to insist throughout the elementary algebra upon the use of significant letters, and to devote considerable time to the evaluation of formulae like those for the linear and cubical expansion of solids under increased temperature, for fractional and decimal values of certain letters; and to transform these formulae by the solution for some one of the letters supposed to stand for an unknown quantity. A mere statement of the purposes of the formulae often arouses great interest among the students.

Now the branch of mathematics which is most distinctly applicative in character is the one which we generally neglect in high school, *viz.*, arithmetic. It is not so many years ago that arithmetic had its place in the high school and was required for entrance to college. It was squeezed out by the pressure of other subjects. I believe that we would have a better mathematical curriculum today if the arithmetic had been left in, and some of the Euclid dispensed with. But the learned Greek overawed us. I would propose, in short, the restoration of arithmetic to its rightful place in the first year of the high school course.

A manual training high school offers an excellent opportunity to attempt this, for several reasons, chief among which is the constant need for arithmetical skill in the shop work. It should be noted also that college preparation is distinctly of secondary importance in such a school, so that the algebraic exercises need not necessarily adhere to an artificial standard of intricacy.

The Central Commercial and Manual Training High School of Newark, N. J., has undertaken to modify the traditional mathematical curriculum by devoting the first year to arithmetic, the second to algebra through logarithms, and the third to plane geometry. The arithmetic, however, is something more than a review of the work of the grammar school.

The course in commercial arithmetic does not differ essentially from that offered in most commercial schools, except in so far as placing it in the first year constitutes a difference. The course in technical arithmetic may be worth mentioning in detail. At the outset of the course there is presented the significance of negative numbers and of literal quantities. This is not so much for the purpose of algebraic analysis, as to make it possible for the student to summarize arithmetical principles by means of simple formulae and to appreciate the importance of arithmetical processes in the evaluation of such formulae.

The four fundamental processes of arithmetic are extended to include literal expressions, which are simple in form, and the laws of these processes are explained and exemplified. Numerical and literal examples are mingled indiscriminately here, and as well in the study of common fractions which follows. Only two cases of algebraic factoring are presented—the removal of the common monomial factor, and the perfect trinomial square, which is applied in arithmetical square root.

Ratio and proportion are emphasized, with applications to similar figures, to specific gravity, to the lever, the inclined plane, the pulley, and the screw, and to the chemical law of constant proportions. Literal as well as numerical examples are presented under this topic. Percentage and interest are reviewed, and their principles summarized in formulae. The metric system comes in for a large share of attention, with transformations to other United States standards.

A large measure of geometry (de-Euclidized) is presented under the alias of mensuration; and this is extended in the way of application to the principles of denominate numbers. The use of cross-section paper in illustrating mathematical relations is introduced at this time, and the effort is made to develop in the mind of the student some notion of the function concept.

Throughout the first year course emphasis is laid upon two points, first, the statement of the solution of a problem in symbolic form, and with it the generalization of the solution by the use of literal numbers; and second, the application to particular

cases of general methods of solution. In a word, the aim is to acquaint the student with algebra as a generalized arithmetic, and with arithmetic and simple geometry as fields for the application of algebra. Ample time is reserved, however, for the consideration of specific problems which may arise in the shops.

As this course has been in operation less than two years, it is too early to report upon its influence upon the work in formal algebra and geometry. But my own faith in its beneficence is very strong. The *need* for both algebra and geometry is brought out very clearly in the first year, and their practical value is made so plain as to be unmistakable. The review of particular topics in arithmetic serves to gather up the loose ends of the mathematical work of the grammar schools. The fundamental principles of numbers are more distinctly defined than in the grammar school would be considered desirable. And as has been seen, the scope of the subject has been enlarged somewhat. This change I am sure is justifiable. There is no reason, for example, why a student should postpone his knowledge of the meaning of the term "horsepower" until he has mastered or memorized certain highly metaphysical ideas regarding the absolute unit of force. The computation of the horsepower of a steam engine, or of the horsepower required by a hydraulic pump is really nothing but arithmetic mingled with a little common sense.

I would go even farther in holding the opinion that the students entering college would be in much better mathematical trim if arithmetic were required for college entrance. I believe that arithmetic in the rightful place as a correlative of algebra and geometry would dispose effectually of many of the absurd formalisms for which high school teachers are now held responsible.

Finally, and not of the least importance, is the fact that the student who for economic or other reasons is able to spend but one year in high school may under the above arrangement acquire a body of information of considerable value, in place of the rattling bones of a dead science.

PROBLEM DEPARTMENT.

By. E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

334. *Selected.*

Factor $a^2(b^2-c^2)^3+b^2(c^2-a^2)^3+c^2(a^2-b^2)^3$.

I. *Solution by A. H. Hughey, El Paso, Texas, and G. A. Van Derhule, Suffield, Conn.*

Expanding we get

$$\begin{aligned} a^2b^6-a^2c^6+b^2c^6-b^2a^6+c^2a^6-b^6c^2 &\equiv c^6(b^2-a^2)+a^2b^2(b^4-a^4)-c^2(b^6-a^6) \\ &\equiv (b^2-a^2)[c^6+a^2b^2(a^2+b^2)-c^2(b^4+a^2b^2+b^4)] \\ &\equiv (b^2-a^2)(c^2-a^2)[c^2(a^2+c^2)-b^4-a^2b^2] \\ &\equiv (b^2-a^2)(c^2-a^2)(c^2-b^2)(a^2+b^2+c^2) \end{aligned}$$

II. *Solution by W. J. Risley, Decatur, Ill., and H. C. McMillin, Lawrence, Kan.*

$$f(a, b, c) \equiv a^2(b^2-c^2)^3+b^2(c^2-a^2)^3+c^2(a^2-b^2)^3$$

is a function of degree 8 in a, b, c, of degree 6 in each of these letters and involving only even powers of them.

$$\therefore f(a, a, c) = f(a, b, a) = f(a, b, b) = 0,$$

$f(a, b, c)$ is divisible by $(a-b)(b-c)(c-a)$.

$$\therefore f(a, -a, c) = f(a, b, -a) = f(a, b, -b) = 0,$$

$f(a, b, c)$ is divisible by $(a+b)(b+c)(c+a)$.

Hence, $f(a, b, c) \equiv (a^2-b^2)(b^2-c^2)(c^2-a^2)F(a, b, c)$,

where $F(a, b, c)$ is of degree 2 in each of the letters and contains no odd power of any letter.

$$\therefore F(a, b, c) \equiv a^2+b^2+c^2,$$

and $$f(a, b, c) \equiv (a^2+b^2+c^2)(a^2-b^2)(b^2-c^2)(c^2-a^2).$$

335. *Proposed by F. Eugene Seymour, Trenton, N. J.*

Find a number of three digits, the last two of which are alike, such that when multiplied by a certain number it still consists of three digits, the first two of which are alike and the same as the former repeated ones, and the third is the same as the multiplier.

1. *Solution by Elmer Schuyler, Brooklyn, N. Y.*

As in solution I we have

$$100x+11y = \text{the number},$$

and

$$110y+z = \text{the product}.$$

$$\text{Hence } y = \frac{z(100x-1)}{11(10-z)}.$$

Since $z<11$ therefore 11 is a factor $100x-1$ where $x<10$; that is $100x \equiv 1 \equiv x \pmod{11}$. $\therefore x = 1$.

$$\therefore y = \frac{9z}{10-z} \text{ and } z = \frac{10y}{9+y} = 10 - \frac{90}{y+9}.$$

Since $9<y+9<19$, we select divisors of 90 from 9 to 19; that is 10, 15, 18, which give $y = 1, 6, 9$, and finally $z = 1, 4, 5$.

$\therefore$ the numbers are 111, 166 and 199 with 1, 4, 5 as the corresponding multipliers.

II. *Solution by Norman Anning, North Bend, B. C.*

To solve the "sum"

$$\begin{array}{r} x\ y\ y \\ \qquad z \\ \hline y\ y\ z \end{array}$$

where x, y and z are digits.

Casting out the elevens $z(x-y+y)-(y-y+z)$ is divisible by 11.

This reduces to $z(x-1)$ divisible by 11.

Neither factor can be eleven and z cannot be zero.

$$\therefore\ x-1 = 0 \quad \text{and } x = 1.$$

Since the product ends in z, $yz-z$ must be divisible by 10.

That is, either $y-1$ or z must be divisible by 5.

There are three cases, $y = 1$, $y = 6$, $z = 5$, with the corresponding solutions:

111	166	199
1	4	5
111	664	995

III. *Solution by O. U. Horner, Peru, Ind., and Walter C. Eells, Tacoma, Wash.*

Let x = hundreds' digit.

Let y = tens' digit, also units' digit.

Let z = multiplier.

Let w = tens' digit in first partial product.

Now $100x+10y+y$ or $100x+11y$ = the number, (1)

and $100y+10y+z$ or $110y+z$ = the product. (2)

Set the letters in the position of a numerical problem in multiplication, thus:

$$\begin{array}{r} x\ y\ y \\ \qquad z \\ \hline \quad w\ z \\ w\ z \\ x\ z \\ \hline y\ y\ z \end{array}$$

From this we see that $w+z = y$, (3)

and $w+xz = y$. (4)

From (3) and (4) $xz = z$.

$x = 1$. (5)

From (1) and (2) $z(100x+11y) = 110y+z$.

Substituting for x $z(100+11y) = 110y+z$,

or $100z+11yz = 110y+z$,

and $$z = \frac{10y}{9+y}.$$

This value for z must be an integer less than 10, which is true only when,

$y = 1$, 6, or 9.

Which gives $z = 1$, 4, or 5.

From (5) $x = 1$, 1, or 1.

Therefore the number may be 111 multiplied by 1,
166 multiplied by 4,
or 199 multiplied by 5.

Geometry.

336. *Proposed by I. N. Warner, Platteville, Wis.*

Given any point, P, between the sides of a plane angle. Required to construct the two circles which shall pass through this point and also be tangent to the sides of the angle.

I. *Solution by Wm. B. Borgers, Grand Rapids, Mich., and Oscar J. Jordan, Normal, Ala.*

Let OA, OB, be the sides of the angle, and OC the bisector. Then the centers must lie in OC. Making P the origin, and the X axis parallel to OA, the distance of any point from OA is $c-y$, while its distance from P is $\sqrt{x^2+y^2}$. The center of a circle passing through P and tangent to OA must satisfy the condition that $c-y = \sqrt{x^2+y^2}$, or $x^2 = c^2-2cy$. In order to be tangent to both OA and OB, the center must lie at the same time in OC. Hence the centers are the two intersections of OC with the parabola $x^2 = c^2-2cy$.

Of course the X axis might have been taken parallel to either side of the angle. Having located the centers, a perpendicular from each, to a side of the angle, is the radius of one of the required circles.

II. *Solution by Levi S. Shively, Mount Morris, Ill., and Harry Roeser, Stillwater, Okla.*

Let XYZ be the given angle. Let Q be the symmetric of P with respect to the bisector of XYZ. Draw PQ intersecting YZ in L. Choose M and N on opposite sides of L and on YZ so that NL = LM = a mean proportional of LP and LQ.

The circles through P, Q, M and P, Q, N are the required circles.

The proof is obvious.

III. *Solution by F. Eugene Seymour, Trenton, N J., and H. C. Whitaker, Philadelphia, Pa.*

Denote the point of intersection of the two given lines by A. If P is on the bisector of A, draw a perpendicular to A P through P and construct the inscribed and escribed circles of the triangle thus formed. If P is not on the bisector, take any point O on the bisector for a center and describe a circle tangent to the two given lines. Join P to A and let PA cross the circumference in B and C respectively. Through P, draw parallels to OB and OC; the intersections of these parallels with AO are the centers of the required circles.

337. *Proposed by H. H. Seidell, St. Louis, Mo.*

If three straight lines AA′, BB′, CC′ drawn from the vertices of a triangle ABC to the opposite sides, pass through a common point O, within the triangle, prove

$$\frac{OA'}{AA'}+\frac{OB'}{BB'}+\frac{OC'}{CC'}=1.$$

(Wentworth, p. 247, example 549.)

I. *Solution by R. M. Mathews, Riverside, Cal., and M. H. Pearson, Montgomery, Ala.*

Let h_1, h_2, h_3 denote the altitudes upon the sides a, b, c respectively, and x, y, z the perpendiculars from O upon the sides.

Then $$\frac{OA'}{AA'}=\frac{x}{h_1},\ \frac{OB'}{BB'}=\frac{y}{h_2},\ \frac{OC'}{CC'}=\frac{z}{h_3}.$$

$$\therefore \quad \frac{OA'}{AA'}+\frac{OB'}{BB'}+\frac{OC'}{CC'}=\frac{x}{h_1}+\frac{y}{h_2}+\frac{z}{h_3}=\frac{ax}{ah_1}+\frac{by}{bh_2}+\frac{cz}{ch_3}.$$

But $ah_1 = bh_2 = ch_3$ = twice area of the triangle;
Also $ax+by+cz$ = twice area of triangle.

$$\therefore \frac{OA'}{AA'}+\frac{OB'}{BB'}+\frac{OC'}{CC'}=\frac{ax+by+cz}{ah_1} = 1.$$

REMARK. The theorem holds for O outside of the triangle if we give a negative sign to each segment where a side is *between* the opposite vertex and O.

Corollary by Nelson L. Roray, Metuchen, N. J.

Since $OA' = AA'-OA$, $OB' = BB'-OB$, $OC' = CC'-OC$,

we have $\frac{AA'-OA}{AA'}+\frac{BB'-OB}{BB'}+\frac{CC'-OC}{CC'} = 1,$

or $\frac{OA}{AA'}+\frac{OB}{BB'}+\frac{OC}{CC'} = 2.$

II. *Solution by Elmer Schuyler, Brooklyn, N. Y., and George Sosnow, Newark, N. J.*

Through O draw ST parallel to BA and VW parallel to AC. Let ST intersect BC in S and AC in T; also let VW intersect AB in V and BC in W. A'A and OA' are homologous lines in the similar triangles SWO and ABC.

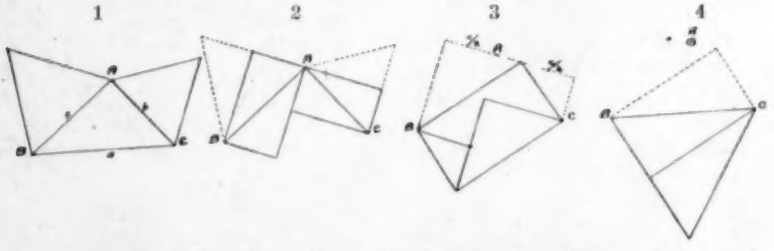
$\therefore \frac{OA'}{AA'}=\frac{SW}{BC}$. Also $\frac{OB'}{BB'}=\frac{WC}{BC}$ and $\frac{OC'}{CC'}=\frac{BS}{BC}$, by similar triangles.

Adding, $\frac{OA'}{AA'}+\frac{OB'}{BB'}+\frac{OC'}{CC'}=\frac{BS+SW+WC}{BC} = 1.$

338. *Proposed by Norman Anning, North Bend, B. C.*

Prove by dissection that the sum of the equilateral triangles described on the legs of a right triangle is equal to the equilateral triangle described on the hypotenuse.

I. *Solution by the proposer.*



II. *Solution by Levi S. Shively, Mount Morris, Ill., and Nelson L. Roray, Metuchen, N. J.*

Let ABF, BCD and ACE be the equilateral triangles constructed upon the hypotenuse and legs of the right triangle ABC. Let CP be the perpendicular from C, the vertex of the right angle, to the hypotenuse. Let PQ be the perpendicular from P to AC. Also let h and k be the altitudes of triangles AEC and BFA respectively.

Now h, k and PQ, CP, are pairs of corresponding lines in the similar quadrilaterals APCE and ACBF.

$\therefore$ PQ : h = CP : k.

Also PQ : h = ΔAPC : ΔACE,

and CP : k = ΔAPC : ΔAPF.

From these proportions it follows that

$$\Delta ACE = \Delta APF.$$

And it may be shown in a similar manner that

$$\Delta BCD = \Delta BPF.$$

III. *Solution by R. M. Mathews, Riverside, Cal., and A. H. Hughey, El Paso, Texas.*

Let ABC be the triangle, right angle at C and K, L, M the vertices of the equilateral triangles opposite A, B, C respectively. Let AK cut BC at X, BL cut AC at Y and CM cut AB at Z.

First: Since C is a right angle and CBK is equilateral it is clear that the altitude of Δ AKC on AC is $\frac{1}{2}$ BC so that

(1) $$\Delta AKC = \tfrac{1}{4}\Delta ABC.$$

In similar manner

(2) $$\Delta BLC = \tfrac{1}{4}\Delta ABC.$$

Next: Δ BAL $\cong$ ΔCAM, ΔABK $\cong$ ΔCBM.

Thus $\Delta ABM = \Delta AZM + \Delta MZB$.

But $\Delta AZM = \Delta CAM - \Delta ACZ = \Delta BAL - \Delta ACZ$,

and $\Delta MZB = \Delta CBM - \Delta CBZ = \Delta ABK - \Delta CBZ$.

$\therefore \Delta ABM = \Delta BAL + \Delta ABK + \Delta ABC$.

$= \Delta AYL + \Delta AYB + \Delta BXK + \Delta ABX - \Delta ABC$.

Using (1) and (2) we have

$$\Delta ABM = \Delta ACL + \Delta ABC + \Delta BCK + \Delta ABC - 2\Delta ABC.$$

Whence $\Delta ABM = \Delta ACL + \Delta BCK$.

CREDIT FOR SOLUTIONS.

329, 330. A. H. Hughey. (2)

334. Norman Anning, A. Babbitt, Julia M. Bligh, Wm. B. Borgers, Maude Furbush, A. H. Hughey, R. O. Hutchinson, R. M. Mathews, H. C. McMillin, Letitia R. Odell, Otto J. Ramler, W. J. Risley, Nelson L. Roray (2 solutions), H. H. Seidell, F. Eugene Seymour (2 solutions), Elmer Schuyler, Levi S. Shively, G. A. Van Derhule, H. C. Whitaker, W. Ralph Wood. (22)

335. Norman Anning, T. M. Blakslee, Julia M. Bligh, Wm. B. Borgers, Walter C. Eells, O. U. Horner, R. O. Hutchinson, R. M. Mathews, A. L. McCarty, L. R. Odell, F. Eugene Seymour, Harry Roeser, Elmer Schuyler, W. J. Risley, Nelson L. Roray, Levi S. Shively, H. C. Whitaker. (17)

336. A. Babbitt, T. M. Blakslee, Wm. B. Borgers, A. G. Bowne, A. M. Harding, A. H. Hughey (2 solutions), Oscar J. Jordan, Chas. H. Klauman, Clarence McCormick, H. C. McMillin (2 solutions), Letitia R. Odell, M. H. Pearson, C. A. Perrigo, Harry Roeser, Nelson L. Roray, Elmer Schuyler, F. Eugene Seymour, Levi S. Shively, W. H. Spurgin, G. A. Van Derhule, H. C. Whitaker, W. Ralph Wood. (24)

337. Norman Anning, T. M. Blakslee, A. G. Bowne, A. M. Harding, A. H. Hughey, R. M. Mathews, A. L. McCarty, Clarence McCormick, H. C. McMillin, M. M. Pearson, Otto J. Ramler, Harry Roeser, Nelson L. Roray, Elmer Schuyler, F. Eugene Seymour, Levi S. Shively, B. F. Sinclair, George Sosnow, G. A. Van Derhule, H. C. Whitaker. (20)

338. Norman Anning, T. M. Blakslee (3 solutions), A. G. Bowne, A. H. Hughey, R. M. Mathews, Lillian McHenry, Levi S. Shively, Nelson L. Roray, (10)

Total number of solutions, 95.

PROBLEMS FOR SOLUTION.

Algebra.

350. *Proposed by H. E. Trefethen, Waterville, Maine.*

Find the value of $2(\sqrt{-1})^{3\sqrt{-1}}$ correct to four decimal places.

351. *Proposed by F. Gilman, Boston, Mass.*

A fancier had a number of rabbits which he disposed of at n auction sales. At the first sale he sold one-half of all the rabbits plus one-half of one rabbit. At the second sale he sold one-half of all the remaining rabbits plus one-half of one rabbit. He continued to do this at n successive sales and at each sale he sold only whole rabbits. After the nth sale he had only one rabbit left. How many did he have at the beginning?

Geometry.

352. *Proposed by Elmer Schuyler, Brooklyn, N. Y.*

Construct a right triangle having given the hypotenuse and the bisector of the right angle.

353. *Proposed by Nelson L. Roray, Metuchen, N. J.*

In the triangle ABC three concurrent rays from the vertices A, B, C meet the opposite sides in D, E, and F respectively. Prove that straight lines through D, E, and F and the corresponding excenters are also concurrent.

354. *Proposed by L. E. Lunn, DeSmet, S. D.*

Given a circle with center O, and points P and Q, to construct a circle passing through P and Q and intersecting an arc of $\theta°$ on the given circle.

Trigonometry.

355. *Proposed by Norman Anning, North Bend, B. C.*

A piece of property ABCDEF has equal frontages on two streets AB and DE. The corner between these streets is "rounded" by a circular arc BCD of 100 feet radius and 80 degree central angle. The straight line boundaries FA and FE are at right angles to the streets and the area is one acre. Find AB.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

107. *From Crew's General Physics.*

A clock having a pendulum 60 cm. long keeps correct time. The pendulum is lengthened to 60.5 cm. How many seconds will the clock lose per day?

108. *From Crew's General Physics.*

From the basket of a balloon hangs a spring balance. This balance carries a mass of 100 gm. The balloon ascends with an acceleration of 220 C. G. S. units. What will be the apparent weight of the 100 gm. during the ascent?

109. *Proposed by Wm. B. Borgers, Grand Rapids, Mich.*

By lifting on the handle-bars, a bicycle rider can exert, during part of the stroke, a force greater than his weight, though during most of the stroke the force is certainly less. Let us assume that the mean effective force is equal to his weight, which is a pretty high estimate, but not impossible. Let the length of crank be 7 inches, gear 80 (which means that for each revolution of the cranks the machine is driven forward a distance of 80x3.1416 inches). Weight of rider 175 pounds, weight of machine 25 pounds. If the chain and bearings have an efficiency of 75 per cent, and the rest of the system 80 per cent, what is the steepest grade that he can ascend at uniform motion? (Grade means ratio of height to horizontal distance.)

Answer serially numbered questions from the following papers:.

DARTMOUTH COLLEGE PHYSICS ENTRANCE EXAMINATION.

September, 1912.

[Answer only six questions.]

1. Name the three fundamental units in the C. G. S. system. Define acceleration, force, work, dyne, erg.

2. Give an example of a body possessing potential energy; kinetic energy? What is the numerical measure of each? How may energy be created or destroyed?

110. The pitch of the screw of a jack-screw is 2 cms. and the lever is 3 meters long. If the efficiency of this machine is 20 per cent how much can a man lift with this screw if he exerts a pull of 50 kilos on the end of the lever?

4. State the law which connects the volume and pressure of a gas at constant temperature. From what do we get our idea of absolute temperature? What is the absolute zero?

5. Heat is applied to 50 grams of ice at 0° C. until it is changed to steam at 100° C. Describe the changes which take place and state the amount of heat involved in each change.

6. Describe with diagrams the principles and action of a modern telephone.

111. A lantern slide is placed six inches behind the projection lens of a lantern. The screen is twenty feet from the lens. What must be the focal length of the lens to throw a distinct picture on the screen?

Draw a diagram showing accurately the formation of the image.

8. Explain the origin and meaning of the dark lines in the solar spectrum.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

[PHYSICS. June, 1912. Time: two hours.]

1. Explain carefully the difference between velocity and acceleration, power and energy, density and specific gravity, momentum and moment of a force.

112. A beam 40 feet long rests upon two supports 20 feet apart. Where must the supports be placed so that one will carry twice as much weight as the other?

113. A freely falling body passes over 176.4 meters while its velocity increases from zero to 58.8 meters per second. How long is it in falling? What acceleration does it have?

114. A lump of ice floats in a vessel of water. How will the height of the water in the vessel be affected if the ice melts? Give your reason in full.

5. Explain in detail, with diagrams, the difference between dispersion and refraction. What is the shortest mirror in which a six-foot man can see his full-length image? Give diagram.

6. What is the difference in principle (not construction) between a mercury barometer and a mercury thermometer?

Explain how evaporation differs from boiling. How are they influenced by height above sea level?

7. Sketch the magnetic field (*a*) between two like poles, (*b*) between two unlike poles. Why are not voltaic cells used for house lighting? What is a condenser?

115. Sixteen small electric lamps are to be used to light a Christmas tree; each has a resistance of 12 ohms and requires a current of half an ampere. If they are connected in series, what voltage must be applied? If they are connected in parallel, to a battery, what voltage must be applied, and what current will flow from the battery?

WOMEN IN THE PUBLIC SCHOOLS.

How women have advanced from the educational ranks to the highest administrative positions in the public schools is interestingly revealed in figures just compiled by the United States Bureau of Education. Four States—Colorado, Idaho, Washington, and Wyoming have women at the head of their State school systems, and there are now 495 women county superintendents in the United States, nearly double the number of ten years ago.

In some States women appear to have almost a monopoly of the higher positions in the public-school system. Wyoming has a woman State superintendent, the deputy State superintendent is a woman; and of the fourteen counties in the State, all but one are directed educationally by women. In Montana, where there are thirty counties, only one man is reported as holding the position of county superintendent.

The increase in the number of women county superintendents is most conspicuous in the West, but is not confined to that section. New York reports 42 women "district superintendents," as against 12 "school commissioners" in 1900. Other States showing marked increases are—Iowa, from 13 in 1900 to 44 in 1912; Kansas, from 26 in 1900 to 49 in 1912; Nebraska, from 10 to 42 in the same period; North Dakota from 10 to 24; Oklahoma, 7 to 14. In only two States is a decrease reported—Tennessee had 9 in 1900 and only 5 in 1912, and Utah has one less than a decade ago.

Together with the advancement of women in the administrative branch of education has come a demand for women on local school boards, and this demand has been recognized in many communities. The following cities of 100,000 population or over report one or more women on the school board: New York, Chicago, Cleveland, San Francisco, Milwaukee, Washington, Indianapolis, Rochester, St. Paul, Denver, Columbus, Worcester, Grand Rapids, Cambridge, and Fall River. Numerous smaller municipalities have adopted the idea.

The important place assigned to women in American education has become so usual as to excite little comment in this country; yet American conditions in this respect are the reverse of those of most nations. It is probably safe to say that in no other country in the world are there as many women teachers proportionally as in the United States; in fact men teachers greatly outnumber the women in most European countries.

PHYSICS CLUB OF NEW YORK.

The annual dinner of the Physics Club of New York was held March 29th at the Broadway Central Hotel. About forty members were present. The speakers of the evening were Prof. Harvey N. Davis of Harvard University, and Principal William Wiener of the Newark Central Commercial and Manual Training High School.

Prof. Davis spoke on "A New Way to Teach Some Hard Problems in Mechanics," dealing particularly with Newton's second law. Prof. Davis considers acceleration "the one essentially hard thing in mechanics." He recommended introducing the subject after the presentation of machines, or at least late in mechanics. Newton's second law may be handled most advantageously in the form of a simple proportion, $F_1 : F_2 = A_1 : A_2$, where F_1 and F_2 are any unbalanced forces and A_1 and A_2 the resulting accelerations. An advantage of this method is that the proportion is essentially "fool proof" and can be applied to the solution of practically any problem in unbalanced forces. Further, the difficulties in presentation of absolute and gravitational units disappear.

Members of the club are looking forward with interest to the forthcoming text of which Prof. Davis is the joint author.

Principal Wiener, in "Common Sense Principles in Teaching," outlined some new methods which he has introduced with great success in the school which he heads.

Teaching how to study, is the essentially new feature in his school. The preparation of the lesson as well as the recitation upon it is under the immediate guidance of the teacher of the subject. While requiring longer school hours, it minimizes the time required for home study and appears ot lead to better results.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

This Association held its sixty-fourth meeting at the Wentworth Institute, Boston, Saturday, March 29th. As usual it was a very interesting and helpful occasion. The meeting was called to order by President Griswold who introduced Principal Williston of the Institute. His remarks were apt and to the point. He discussed the nature and trend of today's secondary school education, saying among many other things that there is an unquestionable tendency to make secondary school education for youth from fifteen to twenty years of age meet better than ever before the community needs.

The Secretary made his annual report showing the society to be in a flourishing condition. This was followed by the Treasurer's report showing a comfortable balance in the box.

The report of the committee on new apparatus was presented by its chairman, John A. Packard. This is one of the interesting features of these meetings as here we are brought in touch with the really usable new pieces of apparatus. It is hoped that the inventors and users of these new schemes will write them up for publication in this Journal.

The committee on Magazine Literature presented in its report a compilation of the topics recently printed in various magazines bearing very largely upon the subject of physics. This branch of the work is becoming more and more a helpful part of these meetings.

The committee on Current Events presented through its chairman, F. H. Hadlock, its phase of the work in a very concise form, giving descriptions of physics principles which have been worked out and put into practical shape for the benefit of mankind.

The committee on new books gave its report by a description of two books by Mr. W. H. Timbie of Wentworth Institute on "Essentials of Electricity" and "Elements of Electricity for Technical Students" published by John Wiley & Sons, New York. These are excellent books and have recently been reviewed in this Journal.

Several people were elected to membership in the Association.

Professor Ira N. Hollis of Harvard University then gave a talk on "The Screw Propeller." The talk was characteristic of the man, intensely interesting being illustrated by many lantern slides and very helpful. This was followed by an address on "The Beginnings of the Telephone" by Thomas A. Watson, Braintree, Mass. This was particularly worth while as the speaker had the honor of constructing the first working telephone ever made.

The following officers were elected for the year 1912-13.

President—Fred H. Cowan, Girl's Latin School, Boston, Mass.

Vice-President—William H. Timbie, Wentworth Institute, Boston, Mass.

Secretary—Alfred M. Butler, High School of Practical Arts, Boston, Mass.

Treasurer—Percy S. Brayton, Medford High School, Medford, Mass.

Executive Committee—Clarence M. Hall, Springfield High School; Fred R. Miller, English High School, Boston; Clifford S. Griswold, Groton School, Groton.

After the election the meeting adjourned for luncheon.

The afternoon session was called to order by the new President, Mr. Fred H. Cowan, who introduced Mr. W. H. Timbie of Wentworth Institute who spoke on "Applied Sciences for Plumbers." This address was listened to with rapt attention as the speaker told of doing real to-to-date practical things which enter into every day life.

At the conclusion of this address a tour of inspection of the building took place, all departments being closely examined. It was the unanimous opinion of all present that this had been one of the best meetings in the history of the Association. C. H. S.

INDIANA ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The eighteenth annual meeting of the Indiana Association of Science and Mathematics Teachers was held Friday and Saturday, March 7th and 8th, in Indianapolis.

The first meeting was held Friday afternoon in the auditorium at Manual Training High School with H. M. Ibison, of Marion, presiding. Prof. Milo H. Stewart, principal of Manual Training High School, welcomed the association to the city. The response was given by the president. The pupils of the high school followed with an interesting half hour program consisting of music and lantern slides, showing views of the school and the various activities of their school life.

Dr. A. L. Foley, professor of physics at Indiana University, then gave a lecture on "Modern Physics," illustrating the same with a very interesting set of experiments.

The evening session was held in the Palm Room of the Claypool Hotel. Dr. R. D. Carmichael, professor of mathematics at Indiana University, gave a very instructive lecture on "A Thread of Scientific History."

Dr. J. B. Garner, of Wabash College, followed with a lecture on "Necessary Re-adjustments in the Public School Curriculum." Dr. Garner showed by means of numerous statistics projected on the screen with a

lantern, that our public school curriculum falls far short of the needs of the present age.

The general business meeting was held at Shortridge High School, Saturday morning. The following officers were elected:

President—Everett W. Owen, Indianapolis.
Vice President—M. D. Foland, Shelbyville.
Secretary-Treasurer—Ernest S. Tillman, Hammond.
Chairman of Executive Committee—A. E. Highley, Terre Haute.

After the business meeting the sectional meetings were held as follows:

Biology and Physiography.

This section was called to order by the chairman, Dr. D. M. Mottier, of Indiana University. The first paper was read by Ulysses O. Cox, Indiana State Normal, on "The Fresh Water Mussel." With the aid of many excellent slides Mr. Cox gave a clear idea of the life history of the mussel, its commercial importance and the possibility of exhausting the supply. He described methods of gathering the shells, the enormous quantities taken out of the rivers and method of making pearl buttons. The modes of propagation were discussed and the work done by the government, which seemed to indicate that the streams can be re-stocked. Many questions were asked Mr. Cox, which he answered very satisfactorily.

The next paper was presented by Prof. Geo. I. Christie, of Purdue University, on "The Methods of Teaching Agriculture." Various suggestions were offered as to the best way to attack the new work required in Indiana schools. Since there is no adequate text-book and very few teachers trained to present the work it seemed feasible to teach agriculture as a series of subjects in connection with botany, zoölogy and chemistry. Prof. Christie said a course ought to be organized for the sixth, seventh and eighth grades in the rural schools and a two or four year course for the high school with certain subjects presented each term. Several schools are attempting to cover all subjects presented in agriculture in one year's time. Prof. Christie's idea was to have these subjects presented more thoroughly and distributed throughout a two or a four years' course. He urged practical illustrations in the class room that would set pupils to thinking and working to relate home and school work.

This paper was discussed at some length. It was suggested that the teaching of agriculture is merely to use plants in the most effective way and to make applications of plant science.

Mr. G. W. Kitchen, of the Columbus High School, said that he found the majority of his city pupils not interested in agriculture. The wheat plant and the oat plant did not seem to appeal to them, and they elected the botany course instead of agriculture. The country pupils, almost without exception, elected the course in agriculture.

Dr. Mottier, of Indiana University, suggested that the teacher should select material suited to the conditions in the community in which he was teaching. City pupils have been found to be interested in flowering and garden plants.

Prof. Christie showed a very interesting and instructive exhibit of agricultural apparatus and experiments.

The last paper was presented by Melvin K. Davis, Anderson High School on "Assimilation of Geographical Data." Mr. Davis said that all knowledge seemed worthless except as points of application and urged the use of data which would relate the principles taught to the environment.

Mathematics Section.

Ernest Stirwalt of the Ft. Wayne High School read the first paper on Home Study, the Vital Problem in the Teaching of Mathematics. He reviewed the growing criticism of home study, some critics going so far as to advocate the discontinuance of assignment of home work. He had found that discipline in schools where home work was discontinued was very satisfactory. Lack of home assignments gave opportunity for general reading and for family associations. The thing most desired is independence in thinking. Experiments where classes were conducted with home study and others without were reviewed and these experiments seemed to show that supervised study at school without home assignments were the most successful. Mr. Stirwalt took a middle ground in his discussion and advocated a smaller amount of home study and that more of the class time be given to study of the advance assignment so that the home assignment would be perfectly understood and within the student's ability to master.

Hugh H. Barcus of Shortridge High School discussed Model Building in Solid Geometry. Some pupils have great trouble in visualizing the figures used in solid geometry from flat figures. Examples of mistaken notions of the figures were given showing how the construction of the models brought full understanding to the pupil. Quotations from pupils showed that their success in solid geometry depended on a correct understanding of the figures. The trend toward the vocational in education emphasizes the necessity of showing the practical side of the work and some pupils are easy to reach if they can be made to feel that the work they are doing connects with life work in some way. Examples were cited to show that Mr. Barcus had succeeded through his models in arousing interest in his subject by showing the practical side of the work. Models in metal, paste-board and wood were shown illustrating those figures about which pupils are most likely to have mistaken notions.

Mr. W. F. L. Sanders of the Connersville High School read a paper on The Present Trend in Mathematical Teaching—Is it Wise? Mr. Sanders prefaced his remarks by stating that nearly all his preparation for college had been made at home. He reviewed briefly the things in his training that he thought led to power in thinking. Among these, he placed prominently the training in mental arithmetic. He advocated the constructive side of mathematics and praised highly the work in model building discussed in the previous paper. He insisted on numerical applications of the theorems of geometry and cited a few ingenious plans for carrying out this idea. He also left with several members of the section hektographed copies of supplemental work to show what he was carrying out in his own school.

The meeting of this section, as usual, was characterized by lively discussions. The discussion of each paper had to be closed on account of lack of time.

Physics and Chemistry Section.

The meeting of the Physics and Chemistry Section was called to order by the chairman, Frank B. Wade, in the chemistry lecture room of the Shortridge High School.

The regular program of the meeting was begun by Mr. Hugh M. Ackley of the Manual Training High School, Indianapolis, who gave an experimental lecture on "Some Experiments with Uranium X." The speaker stated at the outset that his point of view would be that of the secondary school man and also pointed out the fact that high school pupils are very much interested in the recent discoveries in physics. Several

slides were shown of the apparatus used to demonstrate the phenomena of radio-activity. The speaker described a series of experiments which he had made with uranium nitrate and showed the decay curve for uranium x and the recovery curve for the parent uranium nitrate. Mr. Ackley obtained a value for λ of $3.59 \cdot 10^{-7}$ which agrees with that obtained by other investigators. Such facts may be used by the high school teacher of chemistry to show that ordinary chemistry is not to be applied strictly in the case of radio-active substances.

Dr. A. I. Foley of Indiana University explained the fact that insulators lose a charge in summer, and suggested the use of electroscopes with small capacity.

Professor Naylor of DePauw University stated that ebonite rods differ in a marked way in their capacity for holding an electric charge.

Mr. Frank B. Wade discussed electrolytic dissociation from the chemist's view point.

Professor Edwin Morrison spoke concerning metallic conduction by electronic movement.

Professor R. R. Ratliff of Central Normal College, talked upon the condition of the medium surrounding a conductor carrying an electric current.

The next paper on the program was given by Mr. W. H. Courson of the Anderson High School, who spoke on "Has Household Chemistry a Place in Our High Schools?" The speaker proposed the question "What sort of chemical information does a girl need?" In order to answer this question three facts must be taken into consideration—(1) the high schools ought to determine the college entrance requirements, (2) college professors do not recognize previous scientific training as given in high schools, (3) no more time is available for the subject of chemistry.

Discussion on "Has Household Chemistry a Place in Our High Schools."

Mr. J. E. Weyant of the Shortridge High School made the point that courses in science must present difficulties to the student and that there is no safe substitute for hard work.

Dr. J. B. Garner of Wabash College stated that the schools generally are causing too much retardation of pupils.

Mr. Frank B. Wade made the point that even practical chemistry may not enable individuals to act quickly and wisely in a new situation. Students in Shortridge High School who had done work in chemistry did not desire a course in applied chemistry.

Professor Naylor of DePauw University suggested that pure science be taught and then the student will make the applications as they are necessary.

Professor Foley of Indiana University said that teachers need not be discouraged because they failed to interest every student in the class.

Dr. Harry N. Holmes of Earlham College gave reasons why high school students were not prepared to do second year work in college chemistry.

Mr. Thomas H. Allen of the New Albany High School described a social welfare exhibit in which samples of bread were shown—the baking powder having been prepared by the students in high school chemistry.

Mr. H. M. Ibison of the Marion High School pointed out that students fail in applying what knowledge they have just as other persons do. Simply because one knows the method of testing impure milk—this is no evidence in itself that one will make the test.

Mr. C. A. Vallance of the Manual Training High School, Indianapolis, suggested that a course in general science should be given in the first year of the high school.

The last paper of the morning was given by Dr. Harry N. Holmes of Earlham College on "Colloids." The speaker performed a number of experiments showing the properties of colloidal solutions and indicated several important commercial applications of the discoveries in this field of chemistry.

Mr. J. E. Weyant proposed the question "To what is the color of colloidal solutions due?"

Professor Edwin Morrison spoke concerning the nature of the light reflected from very small particles in solution.

Mr. E. R. Glenn of the Bloomington High School described Perrin's work on Brownian Movement in which it was found by experiments with various emulsions that Stokes' law extends to the domain of mircoscopic magnitudes; that the laws of perfect gases apply to uniform emulsions; and that the equipartition of energy for rotation as well as for translation holds true for spherical granules.

Dr. H. N. Holmes answered many questions which were suggested by his address.

The Association was a rousing success in every way and now has the largest paid-up membership in its history. The meeting will be held at Indianapolis again next year.

ERNEST S. TILLMAN,
Secretary-Treasurer.

ROADS IN CRATER LAKE NATIONAL PARK.

That there be constructed around Crater Lake a road which will be one of the great scenic highways of the world is one of the recommendations contained in the annual report of the superintendent of the park which has just been made public by the Department of the Interior. "Upon this road," says the superintendent, "one will be from 1,000 to 8,000 feet above sea level, and upon the highest portion of the Cascade Mountains. It would afford an unobstructed view of the surrounding country to the north, the east, the south, and the west as far as the eye can reach. This road when completed will be about 35 miles long."

Crater Lake National Park is situated on the summit of the Cascade Range in south-central Oregon. It has an area of 159,360 acres and is located in the midst of a beautiful mountain country, the principal attraction being Crater Lake, a body of water having an area of 20¼ square miles which is situated in the caldera of an extinct volcano. The lake is surrounded by unbroken cliffs which range from 500 to nearly 2,000 feet in height. The coloring of the water and of the surrounding cliffs presents some of the most striking pictures seen in the western mountain country.

Before the Cascade Range existed the region now included in the State of Oregon was a great lava plateau that extended from the Rocky Mountains to the present Coast Range. Gradually mountain-making forces became operative; the surface of the plateau was arched and there rose the great mountain system which is now known as the Cascade Range. With the hardening of the crust the centers of eruptions became fewer until they were confined to a few high mountains that were built up by the flows of molten lava. In this way were created Hood, Rainier, and Mazama, from whose sides and lofty summits streams of lava poured across a desolate land. Hood and Rainier still lift their snowy caps to the clouds and fling a defiant challange to the mountaineer to scale their steep, ice-covered slopes. Mazama alone is gone, engulfed in the earth from which it came. In what is left of its caldera lies Crater Lake.

ARTICLES IN CURRENT PERIODICALS.

American Mathematical Monthly for April; *5548 Monroe Ave., Chicago; $2.00 per year:* "History of the Logarithmic and Experimental Concepts," Florian Cajori; "Some Inverse Problems in the Calculus of Variations," E. J. Miles; "The Probability Integral Deduced by Means of Developments in Finite Forms," E. L. Dodd.

Auk, The, for April; *Cambridge, Mass.; $3.00 per year, 75 cents a copy:* "Notes on Swainson's Hawk in Montana," E. S. Cameron; "The Fox Sparrow as a Songster," Robert T. Moore; "Bird Migration from the Standpoint of Its Periodic Accuracy," John C. Phillips; "The Relation of Bird Migration to the Weather," Wells W. Cooke; "Notes on the Morning Awakening," Francis H. Allen; "What the American Bird Banding Association Has Accomplished During 1912," Howard H. Cleaves.

Botanical Gazette for April; *University of Chicago Press, Chicago; $7.00 per year, 75 cents a copy:* "The Effect of Certain Chlorides Singly and Combined in Pairs on the Activity of Moth Diastase," Lon A. Hawkins; "A Physiological and Chemical Study of After-Ripening," Sophia Eckerson; "The California Paroselas," S. B. Parish; "The Effect of Some Puget Sound Bog Waters on the Root Hairs of Tradescantia," George B. Rigg.

Condor for March-April; *Eagle Rock, Los Angeles County, Cal.; $1.50 per year:* "The Nesting of the Prairie Falcon in San Luis Obispo County" (with five photos by the author and one drawing by Allan Brooks), William Leon Dawson; "High Tide; Long-billed Dowitchers at Rest" (photo by W. L. Dawson; special illustration); "*Leucosticte tephrocotis dawsoni* —a new Race of Rosy Finch from the Sierra Nevada," Joseph Grinnell; "Bonaparte Gull in the Estero, Santa Barbara" (photo by W. L. Dawson; special illustration); "Great Destruction of Birds' Eggs and Nestlings in the Sierra Nevada" (with two photos by Mrs. W. W. Cooley), A. M. Ingersoll; "Birds Observed in the Summer of 1912 Among the Santa Barbara Islands" (with two photos by the authors), Howard Wright and G. K. Snyder.

Educational Psychology for April; *Warwick and York, Baltimore, Md.; $1.50 per year, 15 cents a copy:* "The Whole and Part Methods of Memorizing Poetry and Prose," Mary E. Lakenan; "The Sleep of School Children," Lewis M. Terman and Adeline Hocking; "Special Classes for Bright Children in an English Elementary School," I. Shaer; "College Freshmen and Four General Intelligence Tests," Marguerite Calfee; "Psychological Tests in Vocational Guidance," Leonard P. Ayres.

Forestry Quarterly for March; *Ithaca, N. Y.; $2.00 per year, 50 cents a copy:* "Erie Outlook System," F. B. Knapp; "The Preservative Treatment of Wood," I. W. Bailey; "Method of Regulating the Yield in Selection Forests," Walter J. Morrill; "South Dakota School Lands," Paul D. Kelletes; "Some Aspects of European Forestry," A. B. Recknagel; "Let's Not Overlook the Woodlots," Alfred Gaskill.

L'Enseignement Mathématique for March; *Stechert Co., West 25th Street, New York; 15 francs per year, 3 francs a copy:* "The Principles of Mathematics in Relation to Elementary Teaching," A. N. Whitehead; "Sur la classification et la construction des courbes transcendantes," E. Turrière; "Sur les spirales logarithmiques osculatrices à une courbe plane," E. Turrière; "Arithmétique générale," E. Dumont; Chronique; Notes et Documents; Bibliographie.

Motorboat, for April 25th; *110 West 40th Street, New York; $2.00 per year, 10 cents a copy; 24 issues per year:* "Motorboat Haunts Through Canada," Robson Black; "Montreal's Motorboat Show," C. G. Davis; "Racing at St. Augustine," W. L. Larned.

National Geographic Magazine for March; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "Oysters: The World's Most Valuable Water Crop" (with 21 illustrations), Hugh M. Smith; "Greece and Montenegro"

(with 24 illustrations), George Higgins Moses; "Megaspelaeon, the Oldest Monastery in Greece" (with 11 illustrations), Carroll Storrs Alden; "Mysterious Temples of the Jungle; The Prehistoric Ruins of Guatemala" (with 10 illustrations), W. F. Sands; "Excavations at Quirigua, Guatemala" (with 23 illustrations), Sylvanus Griswold Morley; "Saving the Ducks and Geese" (with 15 illustrations), Wells W. Cooke; "Wandering Islands in the Rio Grande" (illustrated), Mrs. Albert S. Burleson.

Nature-Study Review for April; *School of Education, University of Chicago; $1.00 per year, 15 cents a copy:* "A Grand Rapids School Garden," Frances Van Buren; "The Bluebird's Housekeeping," S. Louise Patteson; "The Small Crustaceans"—Second Paper, W. C. Allee; "Nature Study in Rural Schools," Bessie B. Kanouse; "The Tobacco-Worm and its Kin," Ellen Robertson-Miller.

Plant World for March; *2419 York Road, Baltimore, Md.; $2.50 per year, 20 cents a copy:* "II. The Bearing of Osmotic Pressure on the Development of Physical or General Chemistry," Harry C. Jones; "The Action of the Rain-Correcting Atmometer," E. M. Harvey.

Physical Review for April; *Ithaca, N. Y.; $6.00 per year, 50 cents a copy:* "The Annealing of Steel in an Alternating Magnetic Field," H. Pender and R. J. Jones; "Conditions of Sensibility of Photo-electric Cells with Alkali Metals and Hydrogen," J. G. Kemp; "The Optical Constants of Sodium and Potassium," R. W. and R. C. Duncan; "A Method of Producing Known Relative Sound Intensities and a Test of the Rayleigh Disk," G. W. Stewart and Harold Stiles; "A Potential and Electrostatic Force in the Field of Two Metal Spherical Electrodes. III. Charge and Capacity," George R. Dean; "Optimum Wave-Length in Radiotelegraphy," A. H. Taylor.

Popular Astronomy for May; *Northfield, Minn.; $3.00 per year, 15 cents a copy:* "The Sproul Observatory of Swarthmore College" (with plates xv to xx), John A. Miller; "The Integrated Spectrum of the Milky Way," E. A. Fath; "Experimental Proofs of the Earth's Rotation," William F. Rigge; "Total Eclipse of the Moon, March 21, 1913," Dr. Edward Gray, E. E. Barnard; "Three Hundred Years of Research on the Motions of the Satellites," Kurt Laves.

Popular Science Monthly for May; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "A Problem in Evolution," William Patten; "The North American Indians of the Plains," Dr. Clark Wissler; "Heredity and the Hall of Fame," Dr. Frederick Adams Woods; "The Man Who Discovered the Circulation of the Blood," Fraser Harris; "Great Erosional Work of Winds," Dr. Charles R. Keyes; "Hospitals, Their Origin and Evolution," Dr. John Foote; "The New Optimism," G. T. W. Patrick; "Welfare and the New Economics," Scott Nearing; "Scholarship and the State," F. C. Brown.

Psychological Clinic for April; *College Hall, Philadelphia, Pa.; $1.50 per year, 20 cents a copy:* "A Second Study of Mental Fatigue in Relation to the Daily School Program," W. H. Heck, University of Virginia; "Politics, Efficiency, and Retardation," Felix Arnold, New York; "Vocational Training as a Preventive of Crime," G. W. Gaylor, Superintendent of Schools, Canton, Ill.

Terrestrial Magnetism for March; *220 Fourth Avenue W., Cincinnati, Ohio; $3.00 per year, 90 cents per copy; five issues per year:* "The Theory of the Earth Inductor as an Inclinometer," N. E. Dorsey; "Description of the C. I. W. Marine Earth Inductor," J. A. Fleming; "Report of the C. I. W. Marine Earth Inductor," C. W. Hewlett.

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 2; *Otto Salle, Berlin W. 57, Germany; 4 M. per year, 50 pf. a copy:* "Ueber eine leicht beobachtbare Luftspiegelung bei Hamburg und die Erklärung solcher Erscheinungen," Dr. W. Hillers; "Zum Beweise des pythagoreischen Lehrsatzes," H. Detlefs; "Zum Peripheriewinkelsatz," Ingenieur Rudolf Henning.

SCHOOLS URGED TO USE TOPOGRAPHIC MAPS.

United States Geological Survey Will Make Special Selections for Use of Any School or College.

For teaching the geography of the United States in the public schools and colleges a strong effort is being made by the United States Geological Survey to foster the use of the Government topographic maps. These maps contain so many details of local interest, showing even the school houses and farm houses as well as every wagon road, with which of course the school children are familiar, that it is said to be an easy matter for teachers to enlist the interest of the pupils in this new type of school map. From an understanding of the particular maps representing their own localities it is but a succession of short steps to lead the pupils to an appreciation of the different types of country portrayed on maps of other sections of the United States. Most of the standard atlas sheets of the Geological Survey of recent issue are printed on the scale of 1 mile to 1 inch, a scale which shows the physical features of the country in very interesting detail.

Show Altitudes at All Points.

With these maps the pupils can determine the altitude of their homes and the steepness of hills and mountains, estimate the grade of wagon roads, work out simple engineering problems such as the drainage of swamps select dam sites for the construction of reservoirs to supply water to imaginary towns or for irrigation, lay out imaginary trolley or railroad lines or canals along the most feasible routes, establish lookout and signal stations on high points for the control of forest fires, and plan many other similar activities.

Government Will Coöperate With Teachers.

The Geological Survey has published 2,200 topographic atlas sheets, covering about 40 per cent of the United States, and on receipt of $3 from any teacher it will supply 50 different maps selected with special reference to the particular requirements of the class it is proposed to instruct in this new kind of geographic study. This selection will include, besides the map covering the area where the school is situated (provided such a map is published), other maps showing all the physiographic forms to be found in the United States—seacoast areas, hilly country, high and precipitous mountain country, swampy areas, regions of innumerable lakes, areas showing dense forests, areas with woodlands interspersed with many streams, lakes, and other natural features.

Maps Sold at Nominal Prices.

If less than 50 maps are desired, a special selection of a less number will be made on request and furnished at the retail rate of 10 cents a copy. Most of these maps, each of which on the 1-mile scale covers about 225 square miles, or 150,000 acres, have been made at a cost for surveying and engraving of $3,500 to $6,000 each, and the wholesale price of 6 cents apiece covers only about the cost of paper and printing. If the areas were surveyed and the maps published by a commercial concern, these maps would need to be sold for not less than $2 to $3 each. The Survey also sells an excellent wall map about 4 by 6 feet, unmounted (in three sections), for 60 cents. This may be included in any wholesale order as part of the $3. Applications and remittances should be made to the Director of the United States Geological Survey, Washington, D. C., who will promptly fill all orders.

GOOD MAP ENGRAVERS SCARCE.

United States Geological Survey Would Like to Get Some.

No finer maps are made than the engraved topographic atlas sheets of the United States Geological Survey. In accuracy of detail as well as in quality of printing the Survey asserts, with little fear of contradiction, that its maps lead all others, wherever printed. Great advances have been made in recent years in various phases of the printing art, but for fine map work, strange as it may seem no process has yet been found equal to the original hand engraving, which is still essentially the same process that it was generations ago. The skilled copperplate engraver who cuts on his metal base the thin lines which reproduce the map is as necessary now as he was during the middle of the last century. Not everyone can be a successful engraver. It requires a fine touch and a good eye. An announcement recently made by the Civil Service Commission indicates that the profession of copperplate engraver is by no means overrun. The Geological Survey wants competent map engravers at salaries ranging from $3 a day when actually employed to $1,600 a year and is having difficulty in finding applicants to compete for the positions. No regular examination is required, but samples of work, properly authenticated, must be submitted. The Chief Engraver of the Survey at Washington will be glad to hear of anyone who wants such a job and who can measure up to the high standard of engraving work required. May 5 is the date set for picking the right men for the places.

A CHEAP AND CONVENIENT RE-ENFORCEMENT FOR TOPOGRAPHIC MAPS.

By. S. S. Visher,

University of South Dakota, Vermillion.

When, new, clean, topographic maps cost but three cents each it did not pay to spend much effort in the care of laboratory copies. However, with the spread of "the increased cost of living" to include even government maps, as evinced by their recent doubling in price, methods which before scarcely would have paid, now become well worth while.

A convenient method of re-enforcement has been tried out on the laboratory copies of the maps and folios at the University of South Dakota. It has worked so well that I have no hesitation in recommending it. The method consists in pasting a strip of Kafft gummed tape on their backs as near the margin as convenient. This 1¼ inch tape interferes in no way with the usefulness of the map, and very greatly decreases tearing or fraying. The life of our maps has been at least doubled by its presence.

This gummed tape costs but 50¢ per roll of 800 feet, or in other words, one-third of a cent per map. Timed tests prove that all the operations required to re-enforce a map (measurement and cutting off the right lengths of tape, its moistening by being drawn over a sponge set in a cup of water, and its application) can easily be done within two minutes. Considering 20¢ an hour as reasonable wages for such work, a map can be re-enforced at a cost of one cent. Assuming conservatively that its life is doubled thereby, the net returns are 500 per cent on the investment. In these hard times what teacher or institution can let such an opportunity pass!

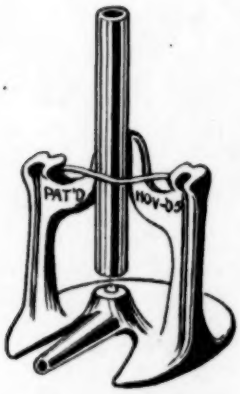
Cloth gummed tape, we have found, but slightly better than the Kafft paper tape. It is half again tougher, but the Kafft tape seems to be suffi-

ciently strong. Since the cloth tape costs a cent a yard or about 2¢ a map the margin of profit is much less. Though after being under pressure over night the Kafft re-enforced maps show not the slightest tendency to curl, the cloth taped maps do not curl even if not subject to pressure while drying.

I have found that the broad blank margins of the topographic maps can be trimmed off in less than a minute and that a decided increase in the handiness and strength results at a very slight increase in cost.

The gummed tape or cloth tape can be obtained from any paper house. We got ours from the Standard Paper Company, of Milwaukee.

A NEW BUNSEN BURNER.



SECTIONAL VIEW OF DIRT TRAP

In general a Bunsen burner is a gas (or vapor) burner in which air is mixed with the gas before it is burned, the burner being so constructed that the amount of air mixed may be varied. The original Bunsen burner was brought out more than fifty years ago, since that time many modifications have been made. Nearly all burners in use are like the original Bunsen, only somewhat simplified and cheapened in construction. They usually have two round holes at the base of the mixing tube, to admit air, a rotating sleeve permits of reducing the air supply or of cutting it off entirely.

These burners have three defects: first, the holes when wide open do not admit enough air to produce the hottest flame; second, the sleeve often sticks because of corrosion, making it impossible to control the air supply; third, the gas inlet often clogs thereby interfering with the gas supply, the location of the inlet nipple being such that it is difficult to clean it.

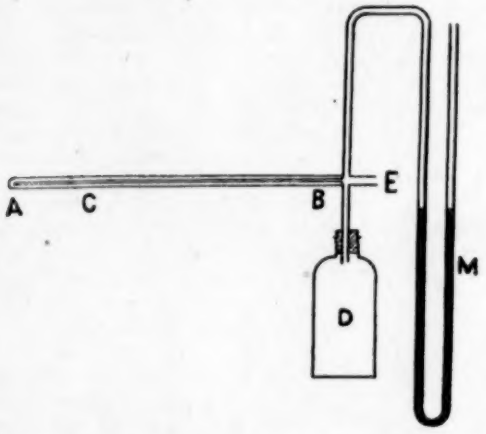
A new burner designed to avoid all these defects, is now being placed on the market. It is of the Terquem type with mixing tube movable up or down to control the air supply. To prevent the tube from sticking, an improved holding device is used. The tube rests in a recess of cast iron, but touches the iron only at the top and bottom of the recess, so that the surface in contact is very small. This greatly reduces the possibility of sticking due to corrosion. A spring holds the tube in the recess but yields enough to allow the tube to move up or down to regulate air supply. A slight pressure combined with a turn of the tube moves it readily. As the tube may be moved up any distance or even removed entirely, it does not prevent cleaning the gas inlet.

An improved nipple to admit the gas to the mixing tube is used. This nipple has the form of a cup or thimble with a small hole in the closed end. The closed end is placed upward so that there is a cavity immediately below the small hole which serves as the gas inlet. The nipple is set tightly in a hole drilled in the cast base, this hole is about one-fourth inch in diameter and connects with the side tube to receive the gas supply. This hole extends downward some distance, below its junction with the side tube, this extension forms a dirt-trap. Any dirt that passes through the small gas inlet will lodge in the trap where it will do no harm. The side tube is tapering so as to fit all ordinary sizes of rubber tubing.

A FORM OF BOYLE'S LAW APPARATUS.

The apparatus is shown diagrammatically in the accompanying sketch. AB is a piece of thick-walled glass tubing about 100 cm. long and about 1.5 mm. in internal diameter; it is closed at A. A thread of mercury C encloses a column of air AC about 25 cm. long.

The open end of the tube is connected to a bottle D (filter flask or Winchester quart), which serves as an air reservoir; it is also connected to a mercury manometer M, the limbs of the latter being about a metre long. The tube E is fitted with a tap or a clip, and communicates with the external atmosphere or with a pump. All rubber-glass joints must be wired.



In order to perform an experiment with the apparatus, the tube AB is clamped horizontally. While E is open to the atmosphere, the length of the air column AC is observed, and also the barometric height. Air is then pumped into the air reservoir by means of a small pump, a football pump being satisfactory. The length of the air column is again read, the change in pressure being obtained from the mercury manometer. The pressure may be raised to two atmospheres without difficulty.

After the pressure has been brought to that of the atmosphere, it may be reduced by means of a filter pump or exhausting syringe until it is about one-third or one-quarter of an atmosphere.

The apparatus has a wider range for its size than the usual form, and the method of varying the pressure appeals more strongly to beginners. The parts of the apparatus can be arranged in a manner convenient for storage purposes, AB being mounted on a hinged board.—*School World.*

MATHEMATICAL LABORATORY.

The Court of the University of Edinburgh have resolved upon the establishment of a Laboratory for practical instruction in numerical, graphical, and mechanical calculation and analysis, as required in the applied mathematical sciences, and for research in connection with the Mathematical Department.

The laboratory will be opened in October of the present year (1913), under the direction of Professor E. T. Whittaker, Sc.D., F.R.S., and the lecturers in the Mathematical department. The nature of the course will be understood from the following schedule:

Course of Practical Work in the Mathematical Laboratory.

Differences and interpolation: computations with tables of logarithms, log sines, natural sines, products, quarter-squares, etc.: numerical solution of trigonometric problems. Controls for checking accuracy of computations: design of computing-forms.

Method of least squares: numerical solutions of systems of linear equations: numerical evaluation of determinants. Curve-fitting. Calculation of correlation-coefficients.

Analysis of a function into sine and cosine terms (practical Fourier analysis).

Analysis for the discovery of periodic constituents in a function (periodogram analysis). Practical spherical harmonic analysis. Other methods of analysis of functions empirically given.

Construction of curves and surfaces: linkages: roulettes. Projections: photogrammetry: map-making. Graphic solution of numerical equations: graphic and mechanical solution of problems in spherical trigonometry: nomography. Applications of triangle of vectors.

Use of instruments employed in calculation, especially slide rules, arithmometers, planimeters, integraphs, and harmonic analysers.

Numerical evaluation of definite integrals.

Numerical solution of differential equations.

Numerical evaluation of roots, etc., of transcendental functions.

Calculations performed with elliptic functions: arcs on spheroids, etc.

Formation and use of tables of Legendre's and Bessel's functions, the Gamma function, Error-function, and other transcendental functions.

Construction of tables of new functions, and functions not previously tabulated, including automorphic functions, and the parabolic-cylinder and elliptic-cylinder functions.

Facilities will be given for original research in these subjects. In this connection, attention may be drawn to the aid afforded by the extensive tables of E. Sang, comprising 47 MSS. volumes, which are deposited in Edinburgh.

Persons (other than present students of Edinburgh University) who wish to take a course in the Laboratory, or to engage in original research in connection with it, are requested to communicate with Professor Whittaker, 35 George Square, Edinburgh, as soon as possible. The University grants recognition, under certain conditions, to Research Students, who are permitted to offer themselves for the degree of D.Sc.

PLANETARY DISTANCES.

By C. E. White,

West Virginia Wesleyan College, Buckhannon, W. Va.

With the exception of the use of the name M. Vem J. Sun to enable the student to remember the names of the planets in their order from the sun, there is not a greater aid to the memory in astronomical study than what is known as Bode's law for the determination of planetary distances. It is, historically considered, the most important of all empirical astronomical laws.

The law is that if 4 be added to each of the numbers 0, 3, 6, 12, 24, 48, 96, 192, 384 (each number except the second being twice the preceding number) and the sums divided by 10, the quotients from left to right will give approximately, the distances of the planets from the sun in astronomical units.

If r be the distance of a planet and n the number of the planet with respect to its distance from the sun, the formula

$$10r = 3 \cdot 2^{n-2} + 4$$

will give the approximate distances except Mercury's distance.

The results given by Bode's law can be found by dividing

$$4x^8 - x^7 - 4x^6 - 4x^5 - 4x^4 - 4x^3 - 4x^2 - 4x - 4 \text{ by } x - 2$$

by synthetic division, and dividing the computed coefficients and remainder by 10. Thus,

4	−1	−4	−4	−4	−4	−4	−4	−4	|2
	8	14	20	32	56	104	200	392	
—	—	—	—	—	—	—	—	—	
.4	.7	1.0	1.6	2.8	5.2	10.0	19.6	38.8	

If we divide

$$4x^8 - x^7 - 4x^6 - 4x^5 - 4x^4 - 4x^3 - 8x^2 - x - 81 \text{ by } x - 2$$

and determine distances by the method given above, we obtain very close approximations to planetary distances. Thus,

4	−1	−4	−4	−4	−4	−8	−1	−81	|2
	8	14	20	32	56	104	192	382	
—	—	—	—	—	—	—	—	—	
.4	.7	1.0	1.6	2.8	5.2	9.6	19.1	30.1	
(.387)	(.723)	(1.0)	(1.523)	(2.767)	(5.202)	(9.538)	(19.183)	(30.055)	

The numbers in parentheses are the mean distances of the planets in astronomical units.

THE TRISECTION OF AN ANGLE BY MEANS OF A GRADUATED RULER AND COMPASSES.

By Clarence Ohlendorf,
Park Ridge, Ill.

To trisect angle XOY. Take OA on OX equal to OB on OY. Join A and B. Draw AM⊥AB and BN⊥BA. Determine C on AB and D on AM subject to the conditions (1) O, C, and D are collinear, (2) CD = 2AO. Determine similarly E on AB and H on BN. This construction can be made by placing a ruler with a fixed point on O and turning the ruler about O as a center until CD = 2AO.

Proof: $\angle CAD = \angle EBH = 90°$, by construction.

$\triangle AOD = \triangle BOH$, by construction.

$\therefore \angle DAO = \angle HBO$.

Complete the rectangle CADK, and let F be the intersection of the diagonals.

Then, $AF = AO = FD$.

Hence, $\angle AFC = \angle a = 2\angle ADF$, where $\angle a = \angle AOC$.

$\angle ACD = 90° - a/2$.

Similarly, $\angle BEH = 90° - a/2$.

Hence, $\angle COE = \angle a$.

Finally we have $\angle AOC = \angle COE = \angle EOB = \frac{1}{3}\angle AOB$.

FOURTH INTERNATIONAL CONGRESS ON SCHOOL HYGIENE.

This congress which will be under the patronage of President Woodrow Wilson, will be held in Buffalo, New York, August 25-30 inclusive. It is the first of the kind ever held in America. Its benefits will be far-reaching, touching every community in the country. Delegates will attend from all leading nations, from all of the more progressive colleges and universities in this country, and from all organizations directly interested in this great problem.

There is now being arranged a comprehensive program of papers and discussions covering the entire field of school hygiene. There will be scientific exhibits, representing the best that is being done in school hygiene, as well as commercial exhibits of practical and educational value to school people. Nor will the entertainment of the delegates in any way be a minor feature. Plans are being made for a series of social events, including receptions and a grand ball, a pageant in the park, and excursion trips to the great industrial plants of Buffalo, as well as to the wonders of Niagara Falls, and the Rapids. Buffalo itself has just taken up a collection of $40,000, for the purpose of covering the expense of the Congress.

Membership may be secured on the payment of a five dollar fee. Applications should be sent to Dr. Thomas A. Storey, College of the City of New York, New York City.

BOOKS RECEIVED.

A First Course in Physics, by Robert A. Millikan and Henry G. Gale, The University of Chicago. Pages x+442. 13x19 cm. 463 illustrations. Cloth. 1913. $1.25. Ginn & Company, Boston.

Modern Geography for High Schools, by Rollin D. Salisbury, Harlan H. Barrows and Walter S. Tower, The University of Chicago. Pages ix+424. vii plates. 281 figures and illustrations. 14x20 cm. Cloth. 1913. Henry Holt & Company, New York.

Annual Report of the Smithsonian Institute for 1911. Pages xii+688. 15x23 cm. Cloth. Government Printing Office, Washington.

Practical Mathematics, by Edward L. Bates and Frederick Charlesworth. Pages xiii+553. 13x19 cm. Cloth. 1912. $1.50 net. D. Van Nostrand Company, New York.

Practical Geometry and Graphics, by Edward L. Bates and Frederick Charlesworth. Pages viii+661. 13x19 cm. Cloth. 1912. $2.00 net. D. Van Nostrand Company, New York.

Chemical Theory and Calculations, by Forsyth J. Wilson. Technical College, Glasgow. 138 pages. 12x18 cm. Cloth. 1912. $1.00 net. D. Van Nostrand Company, New York.

A Text-Book of Physics, in three books, by H. E. Haut. Hertford College. Cloth. 1912. Dynamics and Heat. Pages vi+205. $1.25 net.

Sound and Light. Pages iii+177. $1.25 net.

Magnetism and Electricity. Pages iii+258. $1.50 net. D. Van Nostrand Company, N. Y.

The Principles of Biology, by J. I. Hamaker, Randolph-Macon College. Pages x+459. 14x20 cm. Cloth. 1913. $1.50 net. P. Blakiston's Son & Co., Philadelphia.

Practical Mathematics, Part IV. Trigonometry and Logarithms, by Claude I. Palmer, Armour Institute. Papes xi+147. 12x18 cm. Cloth. 1913. 75 cents net. McGraw-Hill Book Company, New York.

BOOK REVIEWS.

A first Course in Physics, by Robert A. Millikan and Henry G. Gale, the University of Chicago. Pages x+442. 13x19 cm. 463 illustrations. Cloth. 1913. $1.25, Ginn & Company, Boston.

This is a revised edition of the text which appeared about eight years ago and which, during that period had the most extensive sale of any secondary text on this subject published in this country. In the new edition the authors and publishers have profited by the experience, suggestions and criticisms received since the book first appeared. It now embodies practically all of the principles and practices of modern secondary school physics.

Most teachers are familiar with the old edition. We have noted a few of the more important changes: Portraits of some of the best known modern physicists as well as some of those who first made discoveries in physics are given; many new illustrations as well as new and practical problems are introduced. The order of presentation is somewhat changed, viz., the study of liquids and gases being presented first, this in many respects is a splendid departure. Other good features are the elimination, very largely, of the use of absolute units, terms of measurement being given in practical every day language; the treatment of image formation being greatly simplified by a combination of the wave and ray method and a splendid list of review questions and problems being inserted at the end. The book is not as large as the first edition by about sixty pages. There are twenty-one chapters, the matter being presented and discussed in the following order: Measurement, Pressure of Liquids, Pressure in Air, Molecular Motion, Force and Motion, Molecular Forces, Thermomety, Work and Mechanical Energy, Work and Heat Energy, The Transference of Heat, Magnetism, Static Electricity, Electricity in Motion, Effects of Electrical Currents, Induced Currents, Nature and Transmissions of Sound, Nature and Propagation of Light, Image Formation, Color Phenomena, Invisible Radiations.

The book is clearly written, and the subject matter so forcibly presented that it is interesting and makes good reading for the pupil.

Mechanically it represents perfections in book making, the type is large and clear. Major paragraphs all begin with bold face type, the cuts are well executed and to the point. The press work is of the highest degree of efficiency. It is printed from electro plates, and will stand hard usage and doubtless will have as extensive a sale as the first edition.

C. H. S.

Health in Home and Town, by Bertha Millard Brown. Pages vi+312. 14x19 cm. Cloth. 1912. D. C. Heath & Company, Boston.

There is no reason why, in this day and age, a person possessing the elements of ordinary common sense cannot be well and happy. The writer understands perfectly that there are certain environments which practically prohibit some individuals from attaining this state of being. Children should early be instructed in the art of living. That is, how to be well and happy and how to keep so. One of the best books published which will help the child and parent to reach this condition in this very text. It is worded in such a clear and interesting manner that the adolescent child as well as an older person will be fascinated by its diction. The writer put a copy in the hands of his two boys eleven and fourteen years of age. They read it with interest and understanding. The cuts and drawings of which there are 108, have been selected with care and are *apropos* to the subject under discussion. There are twenty-two chapters, each closing with a general summary and a list of questions bearing on the matter mentioned in that chapter. All paragraphs are given, in bold face type, a heading or title. The press work is superb, type clear and large, paper of fine quality, and a book which should be in the hands, for study, of every child in the land.

C. H. S.

Review Questions and Problems in Chemistry, by M. S. H. Unger, St. John's School, Manlius, N. Y. Pages iv+106. 13x19 cm. Cloth. 1912. 50 cents. Ginn & Company, Boston.

This splendid little book is just what secondary school instructors in chemistry need in giving their pupils a thorough review. It consists of a compilation of over one thousand questions taken from the entrance examinations of many colleges, Board of Regents of the State of New York and of the College Entrance Board. The questions have been classified so that the instructor can made his selections fit the particular subject under consideration. The range of questions is such as to cover all the work given in high school, and is arranged under twenty-seven different chapters. It is a book that every chemistry teacher should use in his classes.

C. H. S.

A Text-Book of Mathematics and Mechanics, by C. A. A. Capito, Member of the Institution of Mechanical Engineers. Pages, xv+398. 15x20 cm. Price, $4.00. 1913. J. B. Lippincott Company, Philadelphia.

This book was written for the use of candidates for scientific and higher technical examinations. It assumes that the student has a knowledge of algebra including logarithmic series, of trigonometry including the solution of triangles, and geometry and elementary mechanics necessary to a proper understanding of the higher branches of the subject. The topics are well treated, and in general the simplest and most direct methods are used to derive formulas and the equation of curves, and to solve problems.

Of the 170 pages given to mathematics 64 are devoted to analytic geometry and 104 to calculus. Nothing of importance seems to be omitted, and while the discussions are necessarily brief they are very clear and emphasize the important points.

In mechanics the following topics are considered: The fundamental units; vectors; speed, velocity; acceleration, force; energy, power; motion under gravity; friction; rotary motion; area-moments; moments of inertia; equilibrium of forces; machines; centroids of plane figures; mass-centers; motion of the mass-center; gravitation; the pendulum; hydromechanics; pneumatics; and impact. These topics are treated from a dynamical point of view adequately and without any waste of words. Though no problems are given for solution there are about 250 worked-out problems which should prove of service to the student. As a reference book for instructors and students in engineering courses this volume is of great value.

H. E. C.

Higher Algebra, by Herbert E. Hawkes, Professor of Mathematics in Columbia University. Pages, v+222. 15x21 cm. Price, $1.40. 1913. Ginn & Company, Boston.

This book gives the algebraic work necessary for a course in calculus, and emphasizes the topics which the engineering student finds of especcial service—numerical computations, checks, graphical methods, use of tables, and solution of specific problems. The author, however, considers that these topics are not the substance of algebra, and uses them to furnish "an atmosphere in which the foundations for future work may be well and intelligently laid."

The first sixty-eight pages furnish a review. It is not merely a review for the chapter on graphs gives a much more practical and extensive discussion of the topic than is found in the usual high-school text-books, and the treatment of quadratic equations is sufficiently complete to prepare the student to do better work in the theory of equations and in analytic geometry.

The chapter on complex number includes the graphical representation of complex numbers and their powers and roots. The theory of equations is presented in a way to be more easily grasped by the student, and quite a number of practical problems are given. The twenty pages on determinants will give the student a knowledge of the meaning of a determinant. In the discussion of infinite series only the most important topics are considered and the omission of unnecessary details and the clear statements and explanations should make this rather difficult subject easier of comprehension. The book covers the ground of a course in college algebra and will undoubtedly have a wide use. H. E. C.

Elements of Plane Trigonometry, High-School Edition, by Robert E. Moritz, Professor of Mathematics, University of Washington. Pages, viii+315. 15x21 cm. Price, $1.00. 1912. John Wiley & Sons, New York.

Since the present-day tendency is to include a course in trigonometry in the high-school curriculum, it is important that suitable text-books for the course should be provided. This book is well adapted to the requirements of high-school work, and aims to connect the different branches of mathematics in a practical way and to furnish a solid foundation for future work in mathematics and the sciences.

Some of the noticeable features of the book are: the introduction of the subject with a chapter on the graphical solution of triangles; the exclusion of all principles of higher algebra with which the beginner is unfamiliar; the constant insistence on proper checking of results; limiting the accuracy of results to that of the data employed; arrangement of the logarithmic work in computation; the large selection of actual problems arranged in separate sets taken from surveying, engineering, physics, navigation, geography, astronomy and pure geometry; and the historical notes. There is an abundance of explanations and illustrative examples. The publishers have done their share in producing an attractive and serviceable text-book for high schools. H. E. C.

Culture, Discipline and Democracy, by A. Duncan Yocum, University of Pennsylvania. Pages x+320. 13x19 cm. Cloth. 1913. Christopher Sower Company, Philadelphia.

A book which every teacher who wishes to be in touch with the higher elements of the art of teaching should read and study. Too many instructors believe that the strong point in their profession is to *hear* successfully three or four recitations a day. The highest type of education will only be reached in this country when teachers fully realize that their function is not to cram knowledge and facts into the pupils' minds but that it is to lay the foundations for true manhood and womanhood, in fact, train for the highest type of citizenship. This book "is not so much an attempted solution of the educational problem, as an effort to formulate it." The author investigates and studies the vapory generalizations which are prevalent in current conversation, concerning educational matters, and seeks to apply to present conditions the known facts upon which innumerable partial facts are based. The outcome then of his discussion is not a close drawn deductive conclusion but a collection of many questions which only definite experimentation will successfully solve. If the reader follows closely the author's differentiation of the various questions, not confounding them with his own or others' ideas he will be able to reach an intelligent conception of the problem under discussion.

The author's references to various authorities have been placed together at the end of the book. A twenty page analytic index of topics discussed in the text is appended. The appearance of this book is timely and merits a wide circulation among educators. C. H. S.

School and Home Gardens, by W. H. D. Meier. Pages v+319. 12.5x20 cm. 1913. Ginn and Company.

Though designed as a textbook for the grades, this book will be useful in the high school as well. One is tempted to look at it as a book of reference rather than as a text book. The method of the author is to discuss each of the house and garden plants in turn, grouping these discussions in chapters on decorative plants, annuals, perennial borders, fruit trees, shade trees, and so forth. By this means there is compressed into the volume a great amount of information regarding the care and propagation of plants, and this information may be easily found. It would appear to be a volume to which the pupil would turn for help in particular difficulty. It is not a text book in the sense of outlining a course of study which could be followed more or less closely by a class.

W. L. E.

Hygiene for the Worker, by William H. Tolman, American Museum of Safety; Adelaide Wood Guthrie, American Museum of Safety; and C. Ward Crampton, Director of Physical Training, New York City. Pages vii+231. 13x19 cm. Cloth. 1912. American Book Company, New York.

Nowadays there is no end to the making of good books. This is a splendid work. If every boy and girl would carefully read and then faithfully practice the injunctions mentioned in this book, the health of the individual as well as the general health of the country would be greatly improved. From cover to cover it sets forth the old adage that "an ounce of prevention is worth a pound of cure." It emphasizes the establishment of correct habits on the part of every one, does not advocate the learning of obtuse facts as such, but does insist upon putting into use, at once, the instructions received in the classroom. It is clearly and concisely written, the diction is fine, the reader cannot help but get a right conception of statements made, and there are no errors in expression or statement of facts. Major paragraphs are titled and start with bold face type. The paper is of fine quality unglossed, thus avoiding too much direct reflection of light. The drawings are numerous and illustrate accurately the point considered. There is a five page index. The press work has been done in a workmanlike manner. Mechanically the book represents perfection. All secondary schools should adopt it for daily use.

C. H. S.

Journal of the Proceedings of the Fiftieth Annual Meeting of the National Education Association. Pages xii+1427. 16x23 cm. 1912. Cloth. Ann Arbor, Mich.

This is a comprehensive and valuable report of the work done by the Association at its last meeting. Some folks pooh at such works as this; it simply shows their general caliber. There are many valuable papers printed in this book, and even though one attended the meeting he could not have listened to the reading of but a very small fraction of those here reported. The Association has become very large, dividing itself into all phases of educational work, that the best way for one to get in touch with every branch of work it is doing, is to become a member and thus secure without extra expense a copy of this report which is worth more to the progressive teacher and educator than the price of membership in the Association. The live teacher who wishes to keep in touch with other branches of instruction than his own, will find in this report what is being done by wide awake educators from all parts of the country.

C. H. S.

Industrial Mathematics, by Horace W. Marsh, Pratt Institute, Brooklyn. Pages, viii+477. 227 illustrations. 13x20 cm. Cloth. 1913. John Wiley and Sons, New York.

This splendid book is the outgrowth of the author's experience for several years with his day and evening classes in Pratt Institute. He tried it out in mimeographed form, thus being able to add to the text those ideas, principles and problems which stood successfully the test of class use. The book was written primarily for those who expect to find employment in industrial vocations and for those technical students who wish to have a knowledge of those mathematical processes which are used in real operations. There are thousands of practical problems scattered throughout the book which have been gathered from various sources of a practical nature. There are fourteen chapters with headings as follows: Fundamental Operations; Powers and Roots; Fractions; Weights and Measures; Measuring Instruments; Tapes; Mensuration; Weight; Screw Cutting; Pulleys; Belts; Horse-Power; Solution of an Equation; Logarithms; the Slide-Role; and the Solution of a Triangle. There are, too, several handy reference tables which can be used with the text. The major paragraphs, of which there are 432, are numbered consecutively and each begins with heavy bold face type. The drawings and illustrations are exceptionally well done, showing clearly the points under consideration. The compositor's work is of the highest quality, the mathematical expressions being especially well set. The press work cannot be excelled. Unglossed calendared paper is used. A good index of nine pages is appended. It is just the book for the shop foreman and the practical man who does things worth while. It merits use in all industrial shops and technical schools. C. H. S.

Agronomy, by Willard N. Clute. xi+296 pp. 12½x20 cm. 1913. Ginn & Company.

The appearance of this new text for high schools fits in with the present activity in the production of agricultural text books; but the book itself stands apart. It is not a text-book of agriculture nor yet of botany, though it has relations with both. According to the statement of the author it has been prepared to meet the needs of instruction in urban rather than in rural districts and presents those phases of agriculture which are not remote from the life of the town. Naturally, animal husbandry and field crops are not included.

The principal topics are the soil, fertilizers, tillage, orgainzation of the plant, forcing and retarding, weeds, propagation, decorative planting, pruning, plant diseases, insect pests, plant breeding, origin of species, and cultivated plants. The book is thus organized about the principles and processes of agriculture rather than about particular groups of plants. It is therefore a teachable text book rather than a book of reference. The fact that the author has worked out the materials here represented under city high school conditions adds to the presumptions in its favor. The book must be considered a distinct contribution to the list of text books of agriculture, and one feels that it may well supplement the work in botany in those schools in which no agriculture is offered. The extreme teleological point of view which appears in many places will doubtless receive much criticism but the merits of the book are such as to incline one to pass over such faults.

The press work is well done and the whole makeup of the book exhibits the excellent workmanship which is characteristic of the house which has issued it. The illustrations are so numerous and so happily chosen that one may almost read the book by its illustrations. W. L. E.

Elementary Principles of Electricity and Magnetism, by Robert H. Hough and Walter M. Boehn, University of Pennsylvania. Pages, vii+233. 13x19 cm. Cloth. 1913. $1.10 net. Macmillan Company, New York.

This is a college book and demands as a prerequisite for its understanding a knowledge of analytics and calculus. Its main object is to develop in a logical order the more important mathematical formulae upon which the principles of electricity and magnetism depend. It treats, very largely, with those fundamental expressions which have to deal with machines and instruments in regular engineering practice. The book is intended to be used in connection with lecture demonstrations for presenting the subjects of electricity and magnetism in their various phases. There are scattered throughout the text numerous problems, the solution of which will assist in fixing in the student's mind the principles studied. There is very little descriptive matter given. Major paragraphs are titled and begin with bold face type. The hundreds of mathematical expressions are clearly and well set. There is an index of three pages. The type is large and matter well arranged. The press work has been skillfully done. It is a high class book of its kind. C. H. S.

Seventh Annual Report of the Carnegie Foundation for the Advancement of Teaching, of the President and Treasurer. Pages vi+194. 19x26 cm. Paper. 1912. 576 Fifth Avenue, New York City.

This report is presented in three parts. I. The business of the year. II: Current educational problems. III. De mortuis. The first twenty-two pages of the report are devoted to the detail of the business management of the Foundation in its various phases. The next seventy-six pages are given to discussion of the pension system, especially for teachers, from different points of view, in several states, cities and some countries. It is a comprehensive presentation of this subject as it now stands in educational circles in this country. Part II reviews several current questions of an educational nature, such as: college entrance requirements; admission to advanced standing; medical progress; advertising as a factor in education; education and politics; and sham universities (?). These discussions are to the point, containing much valuable information for persons directly interested in these subjects. Part III is given to short biographical sketches of persons who died during 1912 and who were connected with the Foundation. There are five pages devoted to the treasurer's report which shows receipts and expenditures as well as the character of the securities held by the Foundation. A complete index of ten pages closes the report. A copy should be in the library of every person who wishes to keep in touch with current educational problems.
C. H. S.

Achievements of Chemical Science by James C. Philip, Imperial College of Science, London. Pages vi+217. 12x18 cm. Cloth. 1913. 60 cents net. Macmillan and Company, New York.

One who applies himself closely to the systematic study of a science is liable to lose the helpful influence which comes from the study of general descriptive literature of the particular science. This little book will be a very useful companion to any text is chemistry. It contains many digested facts which have been collected and compiled by the author so that the busy man or student can quickly secure the result of long study and investigation without actually doing the work himself. This book makes good chemistry reading, and will be a valuable addition to every chemist's library. C. H. S.

Elements of Physics, by Edwin H. Hall, Harvard University. Pages vii+576. 351 illustrations, 6 portraits. 13x19 cm. Cloth. 1912. $1.25, Henry Holt & Company, New York.

This book is an out-growth of the third edition of Hall and Bergen's text in physics and shows many important changes and improvements over the original. There is more matter than can be thoroughly mastered in one year by the average secondary school pupil. This is a good feature on Molecular Attraction has been lengthened to twenty pages. The separation of subject and laboratory matter is a wise provision, thus not interrupting the continuity of the reading. There are but few illustrative or lecture experiments, leaving more room for subject matter. Throughout the book are scattered problems and exercises, which will help the reader in fixing the laws and principles already studied. The chapter on Molecular Attraction has been lengthened to twenty pages. The treatment of heat engines has also been improved by the addition of many important and up-to-date discussions. The subject of optics, likewise has been greatly enhanced by the insertion of several interesting topics and electromagnetism has been materially improved. The book is conspicuously free from those mathematical expressions which frighten the beginner of physics. It is a good book and merits an extensive adoption by schools.

There are fifty well selected laboratory exercises at the back of the book and a complete index of eight pages. The book is well made mechanically, the type is clear and large, press work admirable. C. H. S.

Business Arithmetic for Secondary Schools, by Ernest L. Thurston, Assistant Superintendent of Public Schools, District of Columbia. Pages xiv+431. 13x19 cm. Price, $1.00. 1913. The Macmillan Company, New York.

"This book is an attempt to construct the arithmetic instrument logically, in its simplest form, as a branch of mathematics; then to apply this tool to general computation, and to the study, preparation, and interpretation of varied number material. Involved in this is the purpose to develop arithmetic as a language of business, or as a means of interpretation and study of business, and economic conditions; to acquire the capacity properly to present numerical facts by tabulations or graphs; and to cultivate clearness of thought and expression." This paragraph from the preface indicates the author's viewpoint, and an examination of the book will show that he has succeeded well in his efforts. The problems are new and deal with facts within the experience of the pupils. They have not been selected from other textbooks but have been drawn for the most part from home, store, farm, shop, the engineer's office, and other like sources. The book is commended to the attention of teachers of arithmetic. H. E. C.

Solid Geometry, Developed by the Syllabus Method, by Eugene R. Smith, Headmaster of the Park School, Baltimore, Md. Pages xii+211. 13x19 cm. 1913. The American Book Company, New York.

As indicated by the title this book employs the "syllabus" method of teaching geometry, and contains all that the author thinks the pupil really needs, except what the teacher can best supply. The list of propositions is based on the recommendations of the National Geometry Committee of Fifteen. The preliminary chapter, "How to Study Solid Geometry," deals with the relation between solid geometry and plane geometry, methods of attack, and the representation of solid geometry figures. The 601 exercises include about 275 college entrance questions chosen from recent papers set by various colleges.

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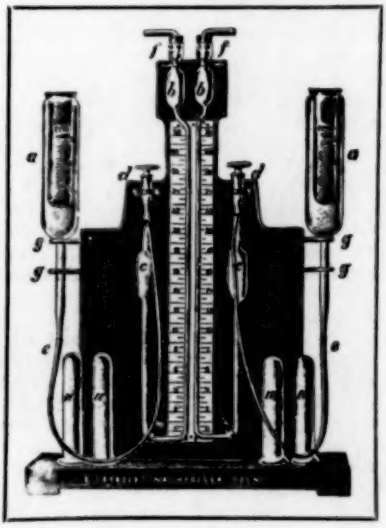

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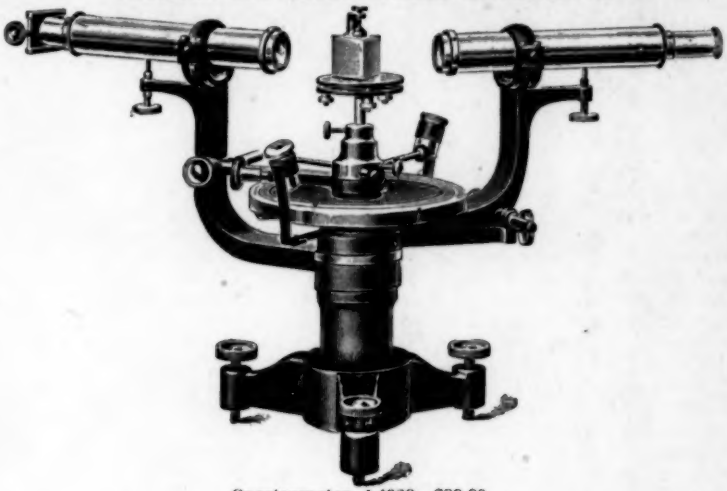

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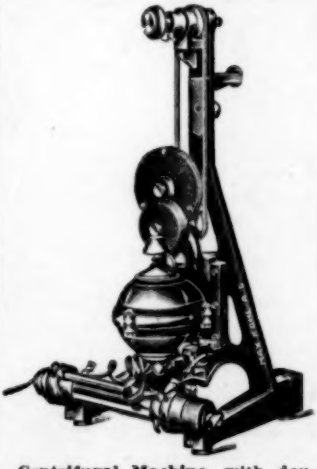

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